Columbia University
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LAMONT GEOLOGICAL OBSERVATORY

PALISADES, NEW YORK

Technical Report No. 15

ONR-27124 Geol.

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PRECISION DEPTH RECORDER MK V

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PRECISION DEPTH RECORDER MK V

by

BERNARD LUSKIN* AND HERBERT G. ISRAEL**

January 1956

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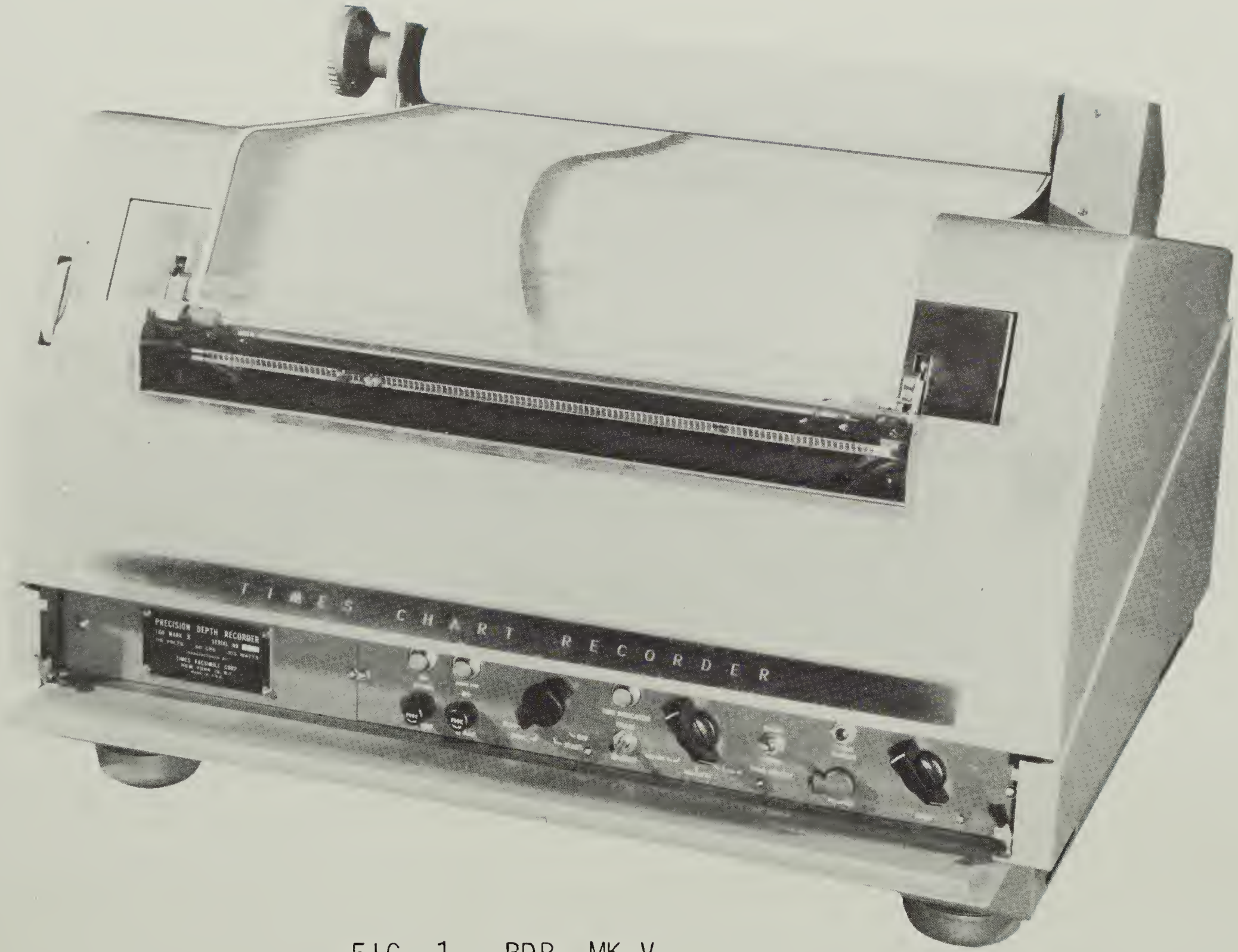

FIG. 1. PDR MK V

FOREWORD

This report consists of an instruction manual prepared by the authors for use with the Precision Depth Recorder MK V equipment. The manual was written to accompany several of these equipments built for the Western Electric Company under Contract XFE 105982 with the Times Facsimile Corporation. Consultant services in the design, development and construction were provided by the Lamont Geological Observatory. These services were performed under the sponsorship of the United States Navy under contracts N6-onr-271 TO 24 with the Office of Naval Research and NObsr 64547 with the Bureau of Ships.

In response to many queries, this manual is here published as a technical report to provide detailed technical information to those individuals and organizations interested in building precise depth recording systems. The design of this equipment is based upon a simplification of the Model MK IV-A. several of which have been in service at sea for about one year. (See Reference A). The size of the MK IV-A has been reduced by one-half and the circuitry and operating controls have been greatly simplified. All previous models of the PDR, MK I-MK IV, have been essentially rough adaptions of Facsimile Recorders. The MK V equipment represents the first model of the PDR which has been built specifically for the job of recording echo sounding pulses on an expanded scale with high precision.

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LIST OF REFERENCES

A. "Precision Depth Recorder MK IV-A", Luskin and Roberts, Technical Report No. 7 N6-onr-27124 Geol., Lamont Geological Observatory, Palisades, New York.

B. "Precision Measurement of Ocean Depth", Luskin, Heezen, Ewing and Landisman, DEEP SEA RESEARCH, Vol. I, No. 3.

C. NAVSHIPS 91420 Instruction Book for Sonar Sounding Set AN/UQN-1B.

D. INSTRUCTION MANUAL FOR WEATHERFAX RECORDER MODEL RJ-2, Times Facimile Corporation, New York 19, New York.

SECTION ONE

GENERAL DESCRIPTION

I. INTRODUCTION

This instruction book covers the essential information for installation, operation and maintenance of the Precision Depth Recorder MARK V. This equipment is the fifth model in a series of recorders originally conceived and developed by members of the staff of the Lamont Geological Observatory of Columbia University. Precision Depth Recorders have been in operation on the Research Vessel Vema, the University's oceanographic research ship, for more than three years. Several of the MK IV type have been in operation on various ships of the U.S. Navy for almost one year.

The MARK V equipment represents a considerable simplification over the MARK IV although the basic principles of operation are the same. The equipment has been reduced in size by one-half. The circuitry and front panel controls have been greatly simplified. Several components which required considerable maintenance, particularly the keying contacts, have been redesigned to insure greater reliability.

Aboard the Vema, the complete recording system consists of two recorders: the expanded scale recorder described here and a synchronized compressed scale recorder, referred to as a Slow Drum. The latter has three main purposes: (1) To aid in resolving the base line of the expanded scale recorder; (2) To provide a summary of the general topography over a wide area on a compact record; (3) To provide an easily reproduced record for publication purposes. The MARK V equipment described here includes provision for connecting a Slow Drum, if required.

II. PURPOSE AND BASIC PRINCIPLES

A. PURPOSE

A sonic sounding system is used to obtain nearly continuous records of ocean depth. The PDR equipment is used to supplant the recorder unit of conventional Sonar sounding equipment. The PDR provides a sounding record with a scale expansion and an accuracy completely beyond the capabilities of conventional sounding equipments.

The scale of the MK V recorder is 18.85 inches equals 400 fathoms or about 1 mm. equals 1 fathom; the estimated accuracy is at least one part in 3000 exclusive of uncertainties in the average vertical velocity of sound. Thus, the record gives a reliable picture of the sea bottom in fine detail. The equipment will operate in any depth of water, being limited only by the power capabilities and signal/noise ratio of the Sonar sounding set installation.

B. BASIC PRINCIPLES

(1) Sounder Unit Functions

A sonic sounding system consists of transducer, transmitter,

receiver and recorder. The transducer converts electrical energy supplied by the transmitter into sound energy which propagates through the sea water and is reflected from the bottom. The reflected sound energy is then converted into electrical energy by the transducer and supplied to the receiver. The receiver feeds the electrical energy of both the outgoing and reflected pulses (pings) into the recorder. The function of the recorder is to time the interval between the transmission and reception of the pings and display the time difference information so that it may be converted easily into depth information. The latter conversion presumes a knowledge of the average vertical velocity of sound.

(2) Function of the PDR

The Precision Depth Recorder performs only the recording function. It is intended to be coupled to the transducer, transmitter and receiver of a conventional deep-water echo-sounder such as the Sonar Sounding Set AN/UQN-1B in place of the recorder units ordinarily supplied with these equipments. The PDR performs the timing function, under ordinary operating conditions, to better than one part in 1,000,000. It displays the timing information on a highly expanded scale so that the fine detail of the bottom is recorded. This high precision is made possible by the tuning-fork-controlled, slip-free drive of the Facsimile-type Recorder. Assuming one millimeter to be the smallest readable unit, the uncorrected depth, as read from the record, is good to ± one fathom. (Conventional echo sounding practice uses a standard velocity of sound of 800 fathoms/second to convert time measurements into depth. This is referred to here as the uncorrected depth).

(3) Programmed Gating Operation

Under favorable operating conditions, the operation of the recorder system is simple. A recording stylus scans the record sheet once per second; one ping is transmitted every second at the beginning of the scan; one ping is received every second and recorded at some time during the scan. This mode of operation gives the maximum density of sampling, of which the recorder is capable, (60 pings per minute), and is referred to as HDR, High Density Recording.

HDR is always used in depths of water down to 1500 fathoms - in such relatively shallow water, the returning echo is strong. In deeper water, where the echoes are weaker, it is not always possible to use the HDR type of recording because the recording of the outgoing ping and reverberation uses up the available dynamic range of a portion of the recording paper which may include the record of the echo. Recording of the scattering layer, especially under noisy conditions, sometimes eliminates a portion of the useful recording area. Poor bottom reflectivity and detuning of the Sonar Receiver may also contribute to low signal/noise ratio.

For such operating conditions, a programming unit is included in the equipment which permits the transmitter and recorder to operate in a preset sequence arranged to minimize the noise on the record while preserving the maximum density of sampling.

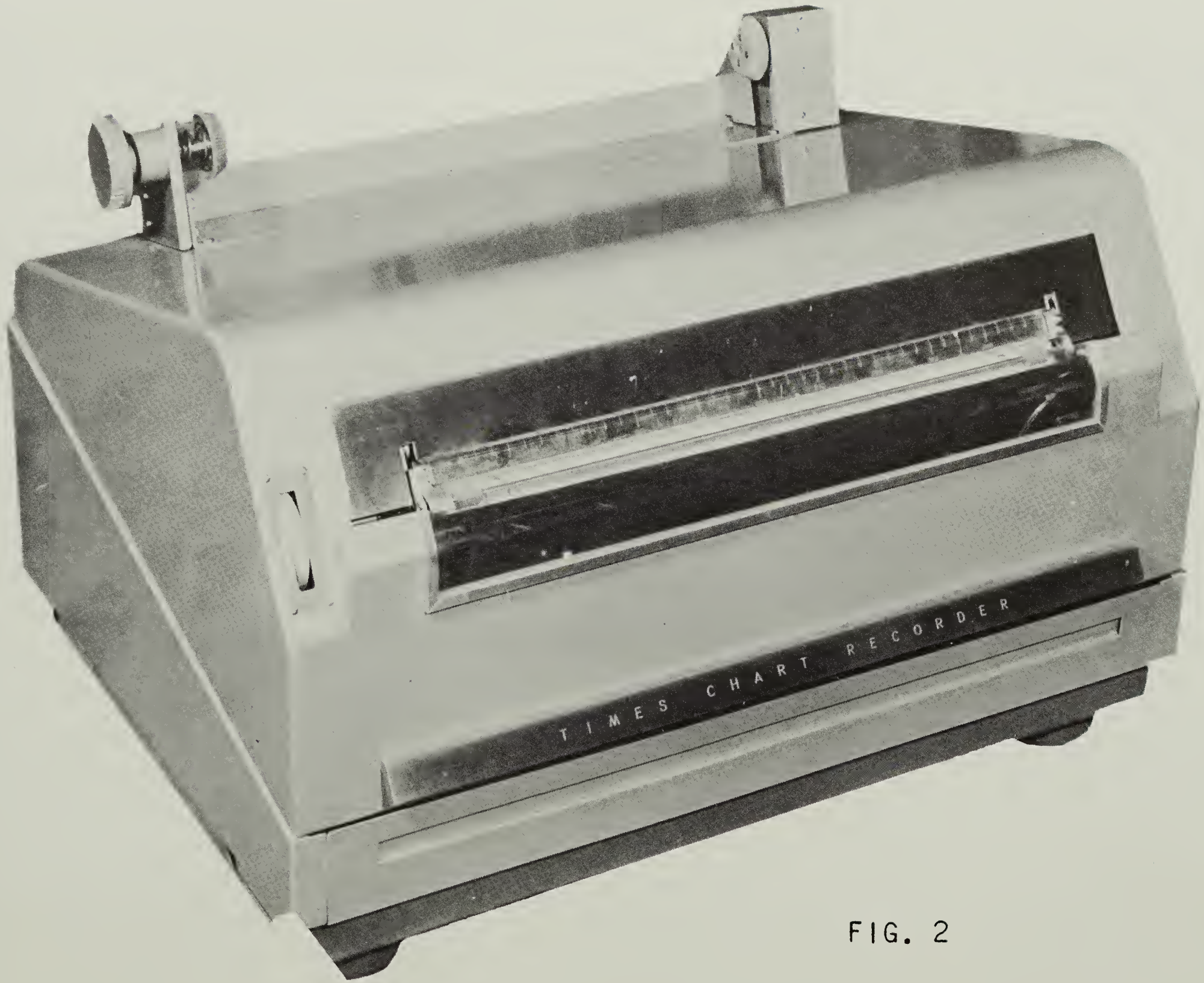


FIG. 2

(4) Time Correlation

For survey purposes ocean depth information is useful only if coordinated with geographical position. Since usual navigation procedure relates geographical position with time (of day), it is practical to display the depth information as a function of time. A cam-switch mechanism is included in the equipment which provides a time mark every three minutes. A phasing clutch mechanism operates the switch so that the recorded time marks may be synchronized, by the operator, with WWV or the Ship's chronometer.

(5) Vertical Scale Exaggeration

The vertical exaggeration of the PDR sounding record is a function of ship's speed only since the depth scale is fixed at 400 fathoms equals 18.85 inches and the paper traverse speed is fixed at 24 inches per hour. A ship operating at 15 knots would have a record exaggerated in the vertical scale by about 30:1. At five knots the exaggeration would be approximately 10:1.

(6) Base Line Determination

The sounding record does not determine the value of the base line, which may represent any multiple of 400 fathoms. An auxiliary Slow Drum recorder, operating in synchronism with the expanded scale recorder readily provides the base-line factor. However, there are several other methods available to the operator for obtaining this information without a Slow Drum. (See SECTION FOUR, Par. II-G).

C. GENERAL DESCRIPTION

(1) Cabinet

The FDR MK V is contained in a cabinet supported on four shock-mounts. Mounted in the cabinet are an exhaust blower, a Mechanical Unit Assembly, and an Electronic Unit Assembly. A paper take-up mechanism is mounted on the hood cover. Figures 1, 2, and 3 show the completely assembled equipment.

(2) Mechanical Unit

The Mechanical Unit is a continuous web-type recorder feeding paper from a 350 foot roll. Three printing styli are mounted on a band assembly which is driven by an induction motor and restrained by an 1800-cycle synchronous motor of the phonic type. The record is printed by burning away the white paper surface with an electrical discharge between the stylus and the frame (ground), thus revealing the black undercoating.

The Mechanical Unit contains a program assembly which provides the various contacts for keying and gating the transmitter and receiver, a 20 cps generator which provides pulses for recording 20 fathom divisions on the 400 fathom record scale, a time-mark switch which interrupts the 20 fathom marks to provide three minute time breaks on the record, and a phasing clutch which enables the operator to synchronize the time marks with the Ship's time standard.

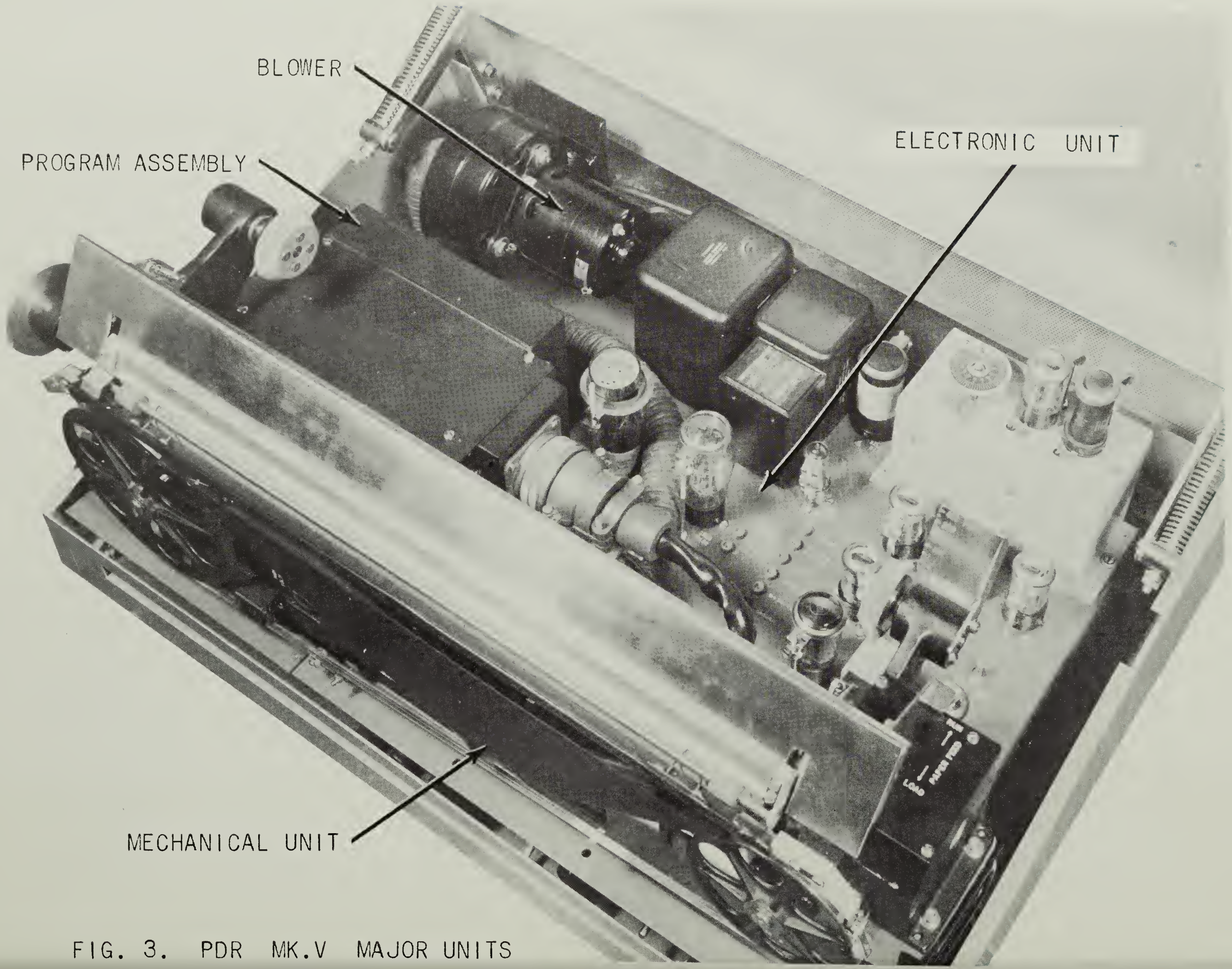


FIG. 3. PDR MK.V MAJOR UNITS

(3) The Electronic Unit

The Electronic Unit contains all the circuitry and controls for coupling the PDR to the Sonar Sounding Set and operating the complete system. The Electronic Unit consists of a Power Supply, an 1800-cycle Fork-Controlled Oscillator, a Sync Motor Amplifier and a Print Amplifier. The cabling connections are made on the Rear Panel. The operator's controls and indicators are on the Front Panel. The Mechanical Unit mounts over the forward end of the Electronic Unit Chassis and one cable interconnects the two units.

D. APPLICATIONS

The PDR MK V is used for recording sonic soundings in place of the recorder units supplied with conventional sounding gear. It is intended for use in deep water surveys where high precision and fine details of relief are required.

For further information on the background and applications of PDR equipment, see Reference B.

SECTION TWO

THEORY OF OPERATION

I. INTRODUCTION

A. GENERAL

The Precision Depth Recorder is a precise timing device which displays the time difference between transmitted and bottom-reflected sonic pulses on an expanded scale. The correlation of this displayed information with the actual ocean bottom topography depends upon many factors beyond the scope of this manual. For present purposes, it is considered that the record obtained is a representation of the ocean bottom beneath the ship and gives the depth in fathoms.

B. SONAR SOUNDING SET

The Sonar Sounding Set is the basic equipment for recording depth. The PDR is intended to replace the recorder unit of conventional sounders which do not provide the expanded scale and high precision required for detailed surveys. Hereafter, the Sounding Set referred to will be the Sonar Sounding Set AN/UQN-1B. Complete information on this equipment is contained in Reference C. For present purposes, this equipment may be considered to consist of a transducer, transmitter and receiver. The transmitter energizes the transducer when it is keyed by a grounding contact. The receiver passes and amplifies both the transmitted and bottom-reflected pulses. The output of the receiver is available at a high-level low-impedance outlet.

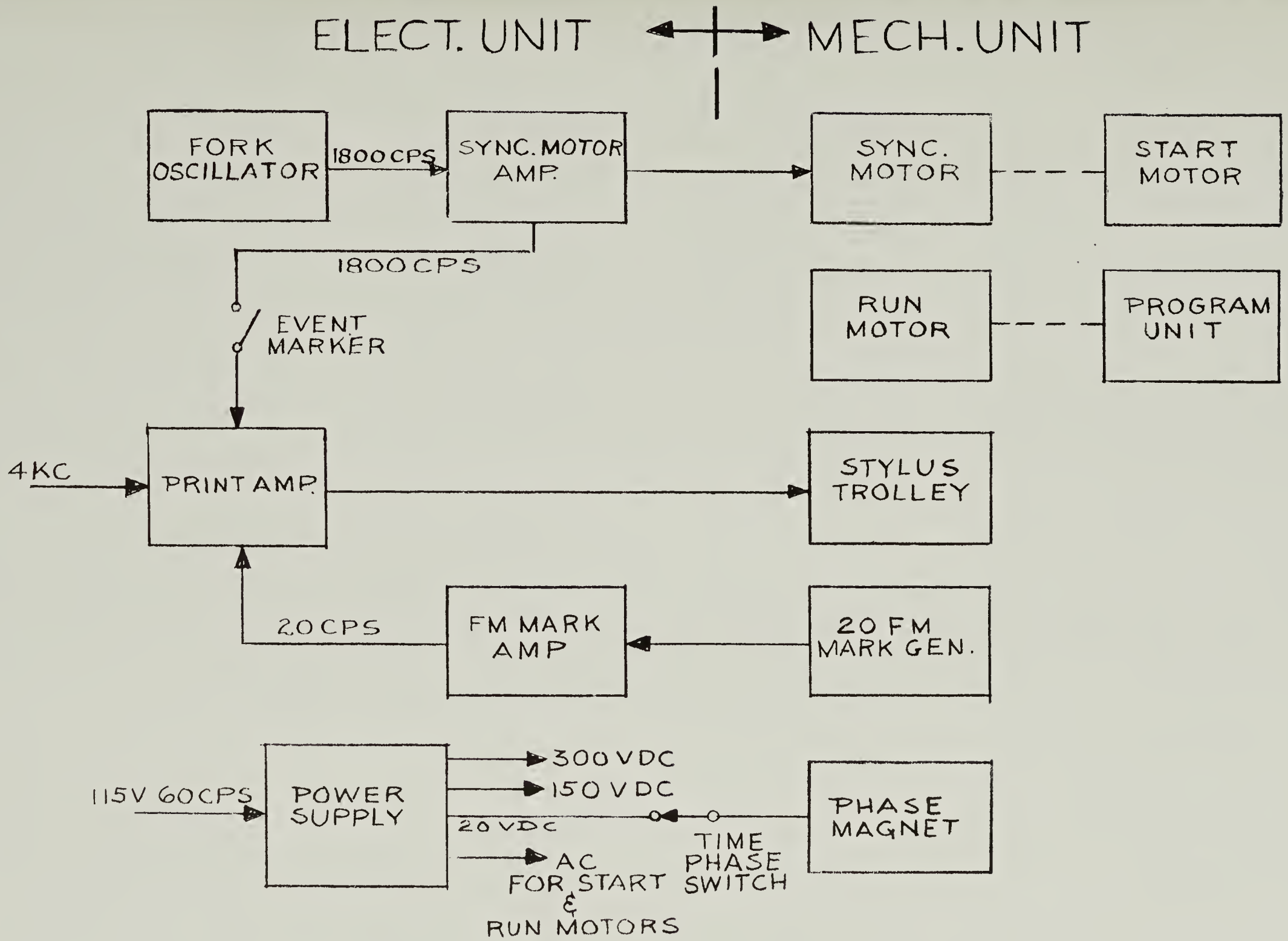
C. PRECISION DEPTH RECORDER

(1) Functions

The PDR has two main functions: (1) to provide a display of the sonic pulse time-difference information in a precise and integrated manner; (2) to provide a keying contact for the Sonar transmitter. In addition, there are several auxiliary functions: (1) to provide 20 fathom divisions on the 400 fathom scale record for ease of reading depth precisely; (2) to provide a time break on the record so that the depth may be related to geographical position by correlation with the ship's log; (3) to provide a means of synchronizing the record time breaks with the Ship's time standard; (4) to provide a programmed gating system. Figure 4 shows the functional relationship of the various units.

(2) Gating System, General

The Gating System in the MK V Recorder is designed to allow a maximum density of sampling and a maximum signal/noise recording ratio while preserving the greatest simplicity of operation. In the range 0-1500



BLOCK DIAGRAM

FIG. 4

fathoms, the operation of the recorder is simple: one ping is transmitted at the beginning of each stylus scan, once per second, and, of course, one ping is received as a bottom reflection per scan. This mode of operation can be used in any depth of water. However, in depths greater than 1500 fathoms, the echo is usually too weak to show through the accumulated noise. In the range 1500-3000 fathoms, a program of keying and recording is controlled by cams operating on a 12 second cycle; in 3000-6000 fathoms, the cycle length is 24 seconds. In addition, if a Slow Drum is used in synchronism with the expanded scale recorder, a 144 second cycle program is available for control of the Slow Drum program.

The operation of the cycles is shown diagrammatically in Figure 5. Zero time is the time of the start of the first of a group of pings. It is also the time of the start of a stylus scan across the recording paper.

(3) Twelve Second Cycle

Consider the twelve second cycle. The keying gate opens just before zero time and closes just after the fifth second, thus allowing six pings to be transmitted every twelve seconds. The recording gate opens at second 3.5, so that two of the six outgoing pings are recorded and also all the reflected pings between 3.5 and twelve seconds. The recording gate is open for eight and one-half scans of the stylus. For depths between 1500 and 2800 fathoms, six of the eight and one-half scans will print an echo return; for depths greater than 2800 fathoms only five or less returns will be recorded.

(4) Twenty-four Second Cycle

Consider the 24 second cycle. The keying gate opens just before zero time and closes just after the eleventh second, thus allowing twelve pings to be transmitted every twenty-four seconds. The recording gate opens at second 7.5, so that four of the twelve outgoing pings are recorded and also all the reflected pings between 7.5 and 24 seconds. The recording gate is open for sixteen and one-half scans of the stylus. For depths between 3000 and 5200 fathoms, twelve of the sixteen and one-half scans will print an echo return; for depths greater than 5200 fathoms only eleven or less returns will be recorded.

(5) 144 Second Cycle

Consider the 144 second cycle. This is used for gating an auxiliary Slow Drum recorder with a full scale of 2400 fathoms (6 seconds per scan). The keying gate, which supersedes the twelve and twenty-four second cycle gates in the circuit, allows 120 seconds of operation as described above. During this time the receiving gate of the 2400 fathom scale recorder is closed and the keying gate is open. Just before second number 120 in the cycle the keying gate closes for five seconds, opens then for one second allowing only one ping to be transmitted, then opens again before second 24 to allow another 120 seconds of normal expanded scale recording. The Slow Drum receiving gate opens in time to record the single ping transmitted and closes just before normal operation begins again. Thus the density of sampling for the Slow Drum is one ping every 144 seconds. When there is no

KEYING & RECORDING PROGRAMS

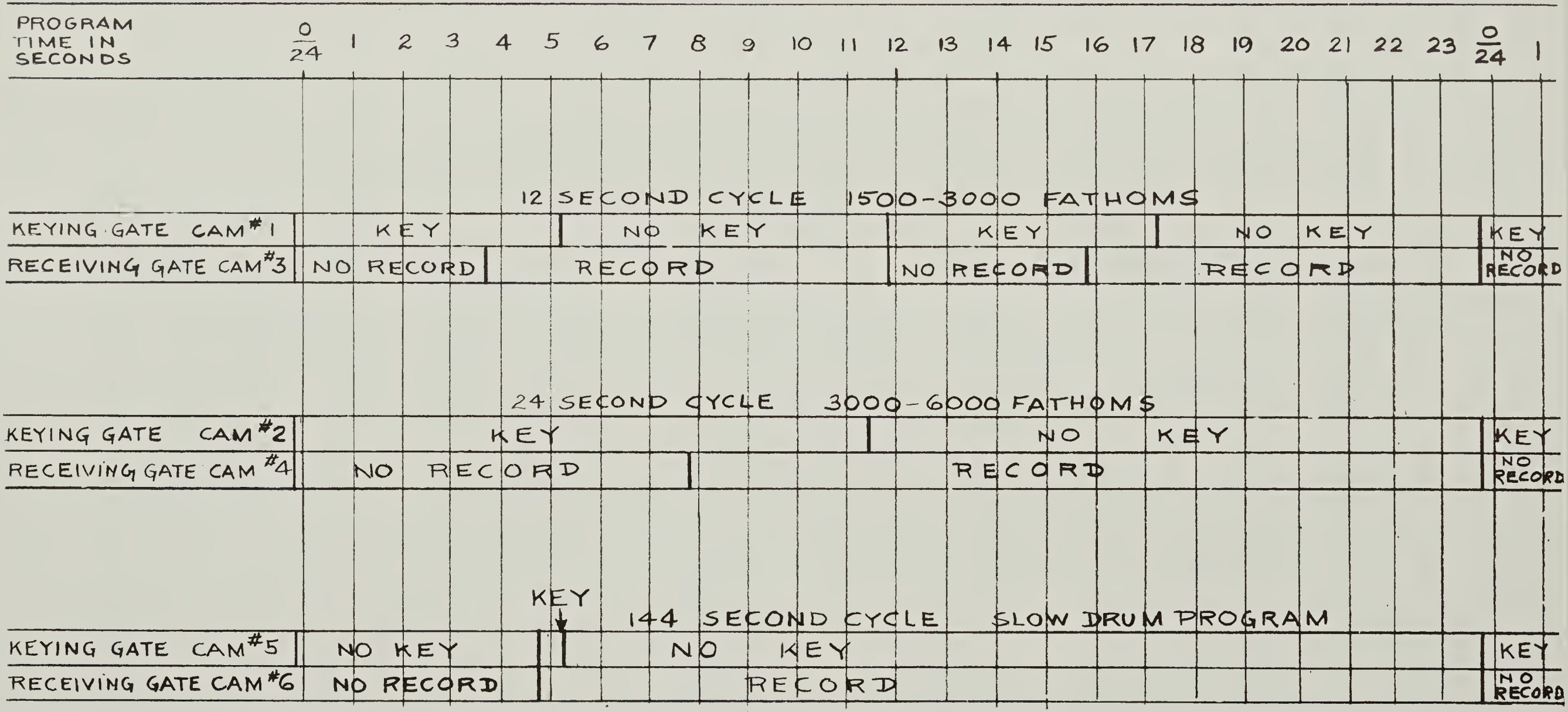


FIG. 5

auxiliary Slow Drum recorder, the 144 second keying gate is bypassed and the normal expanded scale recorder programs are not interrupted.

II. DESCRIPTION OF UNITS AND CIRCUITS

A. SONAR SOUNDING SET

(1) General

The circuits of the Sonar Sounding Set AN/UQN - 1B are described in Reference C. Only those parts of the circuit which have to do with the PDR equipment will be considered here. These are: (1) Motor Drive; (2) Keying Leads; (3) Earphone Output Jack. The illustrations referred to in this paragraph (II-A), are to be found in Reference C.

(2) The Motor Drive

The Motor Drive of the Sounder is connected for a separate 60 cps 115 V source as shown in Figure 3-3, Reference C. If it is desired to run the Sounder Recorder at times, the AC source for the drive motor may be switched. In any case, the motor should be disconnected while the PDR is operating.

The styli must be prevented from recording on the chart area or overloading of the final receiver stage with consequent damage to components will result. The belt holding the recording styli may be advanced manually until neither one of the styli is in contact with the paper; or the connection to the trolley bar may be broken. If it is desired to be able to put the Sonar Set in normal operation quickly, this latter connection may be switched.

(3) The Keying Leads

The Keying Leads are normally connected to the keying contacts, S-201 (Figure 2-9). These are disconnected, and led, through a shielded cable, to the PDR KEYING LEAD jack. If it is desired to operate the Sounder at times, the keying leads may also be switched.

(4) The Earphone Output Jack

The Earphone Output Jack is used as the source of signal for the PDR. A shielded cable leads the signal from this point to the PDR INPUT jack. The PHONES jack, on the PDR front panel, may be used for monitoring.

In order to reduce the line impedance of the signal lead, Condenser C-221 (Reference C), 680 MMF., is shunted by a 0.1 MFD, 600 v condenser.

Aside from the circuit changes mentioned above, the Sounder is operated as usual.

B. PRECISION DEPTH RECORDER

(1) Cabinet

The PDR MK V is contained in a cabinet supported by four shock mounts.

A small hinged cover plate allows access to the front panel operating controls. A paper take-up mechanism, including a small AC motor, a friction clutch and suitable supports for the take-up spool, is mounted on the hood. A lucite window is provided to obtain a clear view of the styli when the hood is in place. Inside the cabinet are the Mechanical Unit, the Electronic Unit, and an exhaust blower, connected by hose to the Mechanical Unit, which removes the waste particles created by the recording process. The blower and take-up motors are cable-connected to the AC line through J7-P7 and J8-P8 respectively, and are energized by the Power Switch in the RUN position. (See Figure 24).

(2) The Mechanical Unit

The Mechanical Unit contains all the mechanical apparatus required to perform the recording function and all the auxiliary devices required to synchronize the operation of the PDR with the Sonar Sounding Set. Connection to the Electronic Unit is made through P1, a 23-pin receptacle mounted on the program assembly. General views of the Mechanical Unit are shown in Figures 6 and 7.

a. Printing

Printing of the paper is done by three styli equally spaced on a band assembly. Signal power is fed to the styli through contact between the styli bushing holders and a Trolley Bar mounted on the front of the Mechanical Unit. The Trolley Bar also helps smooth out the traversing motion of the styli.

The band is driven by a single phase induction Run Motor and restrained by a phonic-type Sync Motor so that each stylus scans the width of the recording chart once per second. The chart paper is fed from a roll at 24 inches per hour.

b. Recorder Drive

Refer to Figures 8 - 11, showing detailed views of the Recorder driving system and Figure 24, the complete circuit diagram.

The Recorder is set in operation by the four-position power switch, S1. Refer to S1-E and S1-F in Figure 24. In OFF position, both sides of the 115V, 60 cps line are disconnected from the Mechanical Unit. In START position, the START MOTOR is energized and brings the SYNC motor above synchronous speed. In SYNC position, the SYNC MOTOR is energized and drops into synchronous speed, 1800 RPM. The START MOTOR is still energized through ballast tube V103 at this stage to provide some damping force on the SYNC MOTOR. Other than this damping force, there is no appreciable load on the SYNC MOTOR, since the latch mechanism linking it to the rest of the drive system slips freely when the RUN MOTOR is stopped. In RUN position, the START MOTOR is disconnected and the RUN MOTOR is energized through ballast tube V103, which regulates the RUN MOTOR current. The RUN MOTOR drives the Band Assembly which engages the SYNC ARM by means of the lug projections on the stylus holders. The SYNC ARM is connected

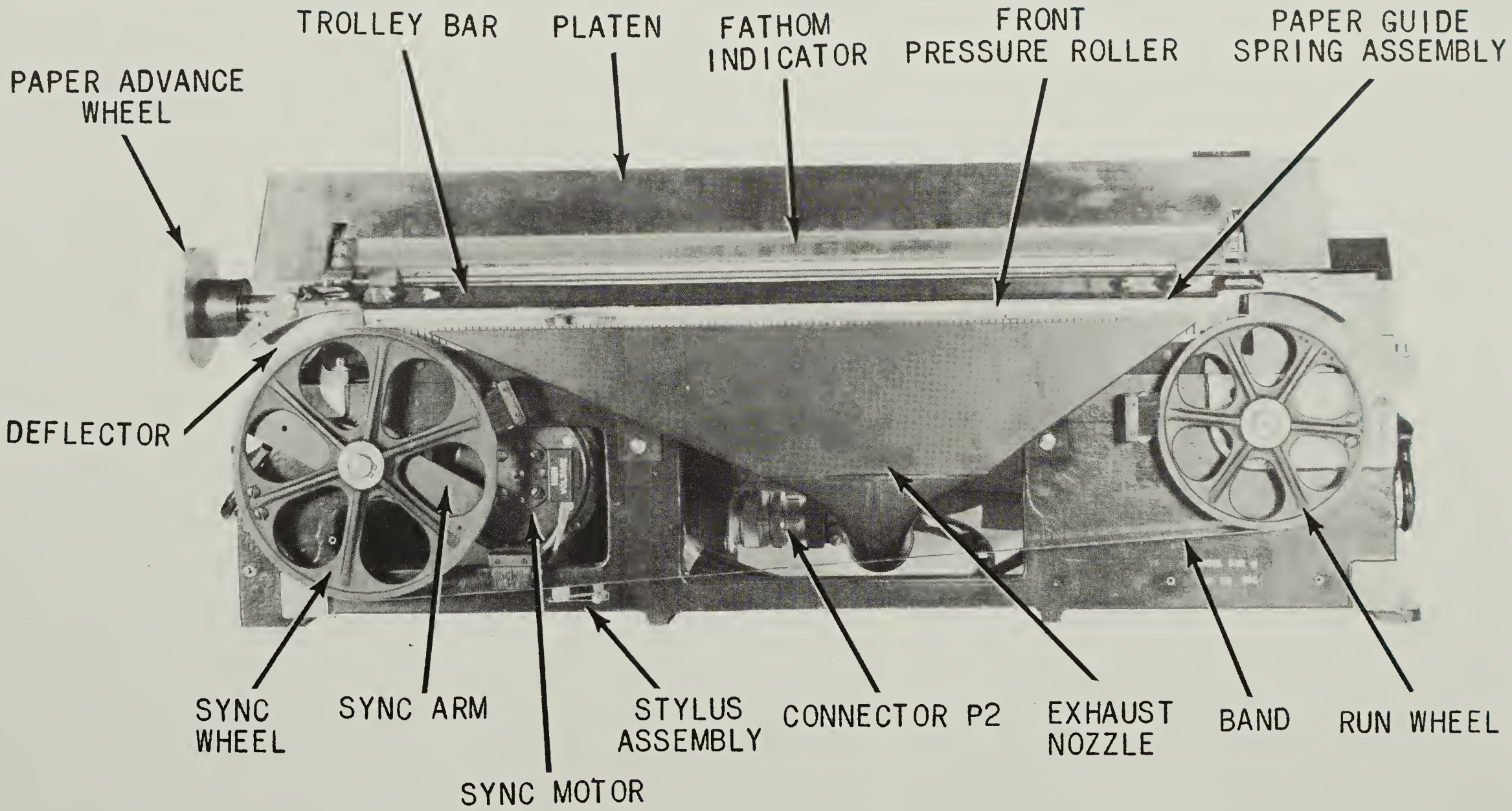


FIG. 6. MECHANICAL UNIT FRONT VIEW

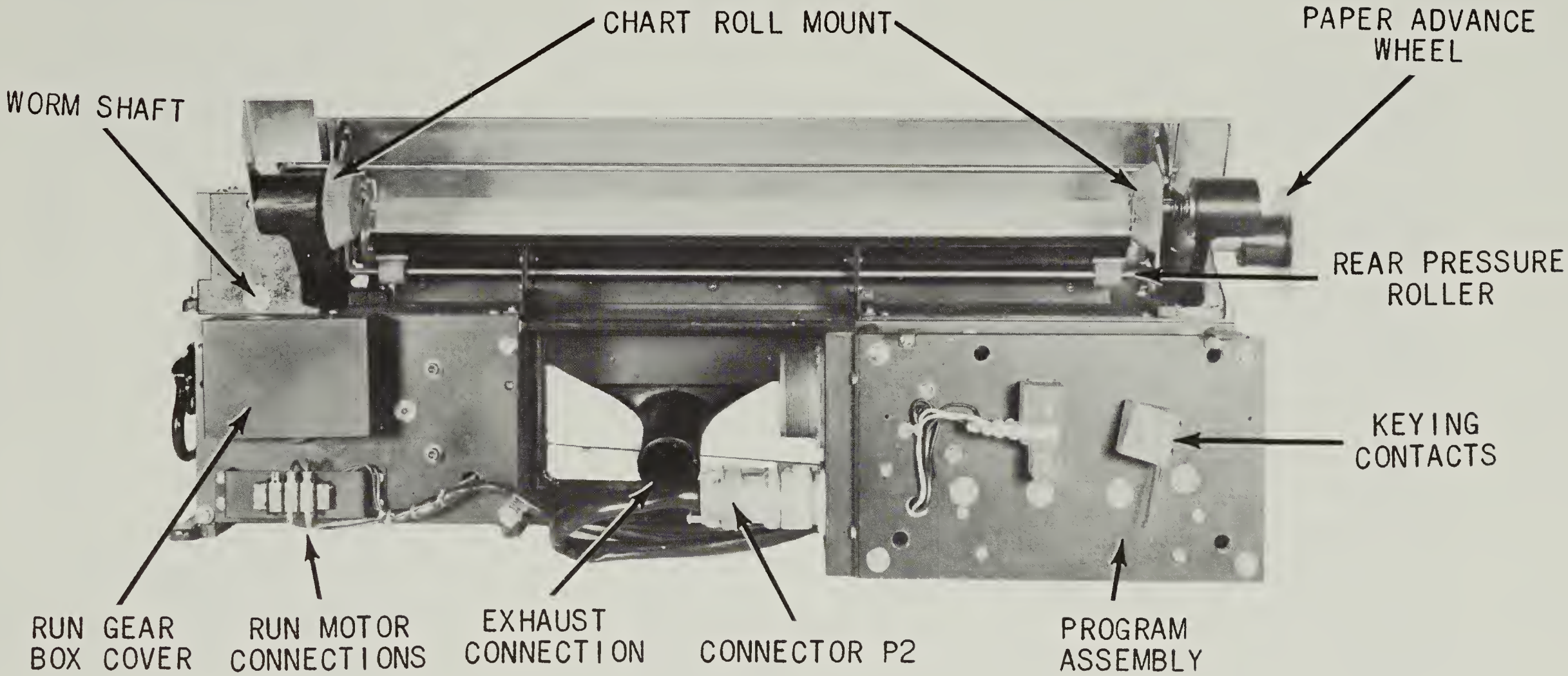


FIG. 7. MECHANICAL UNIT REAR VIEW

In Fig. 2 which shows the Mechanical drive assembly, the band 1 carrying the stylus holders 2 is driven by the non-synchronous run motor 3 through the reduction gears.

The stylus holders 2 have lug projections that catch on the holdback arm 5 which cannot be pulled above synchronous speed (see Fig. 3). The wheel 18 rotates freely about the shaft 19. The shaft 19 of the hold-back arm 5 drives the collar 6 upon which is attached the drive dog 7. The run motor 3 tends to drive the system above synchronous speed, thus causing the drive dog 7 to rotate until it engages the latch 8 mounted on the collar 9. The collar 9 is geared to the synchronous motor so as to run at synchronous speed. The drive back to the synchronous motor is through the gear 17.

When starting up the system preparatory to recording, the synchronous motor 13 is first brought up to speed by the start motor 14. There is no load on the synchronous motor because the latch 8 trips over the drive dog 7 which is not rotating.

When the run motor 3 starts up, it speeds up until the drive dog 7 catches up with the latch 8. The band 1 is then held down to synchronous speed. When the run motor stops the synchronous system between motor 13 and latch 8 continues to rotate at synchronous speed.

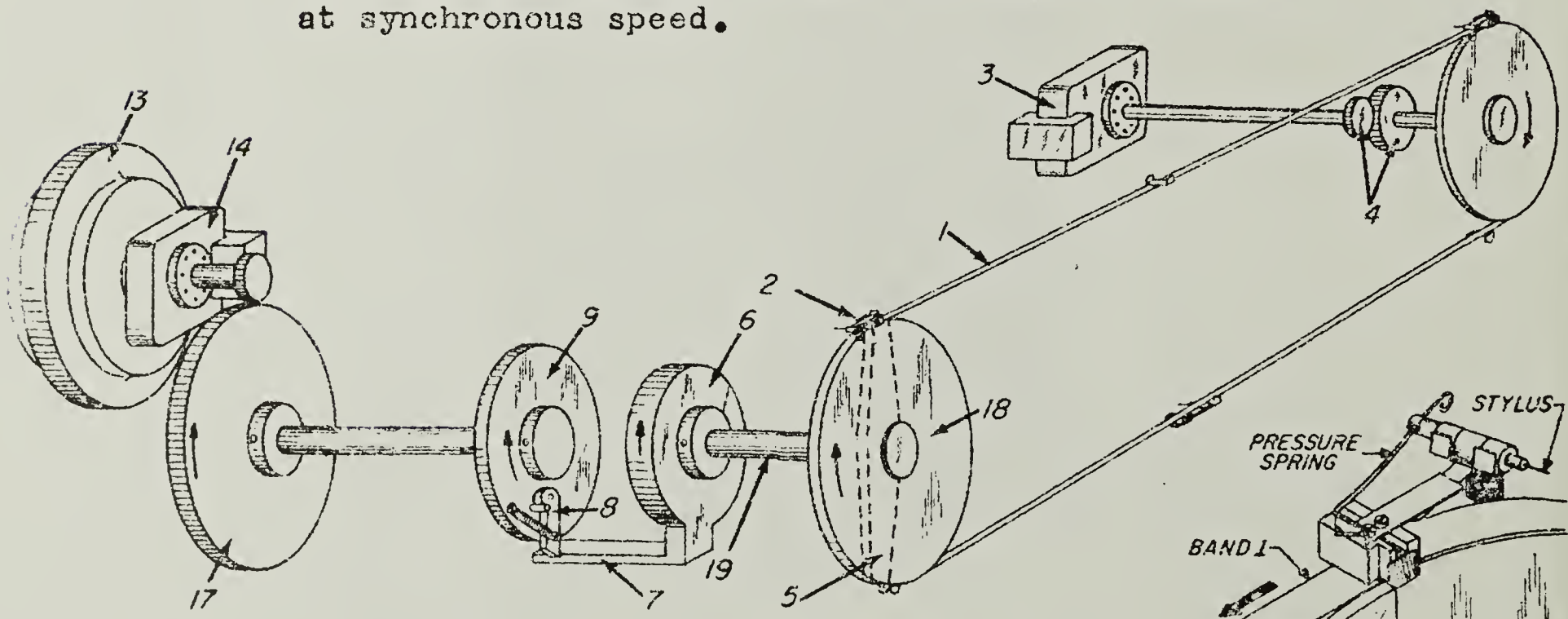


Fig. 2. Synchronous Drive System

Fig. 3. Recorder Stylus and Drive Lug Assembly.

FIG. 8. DRIVE SYSTEM SCHEMATIC

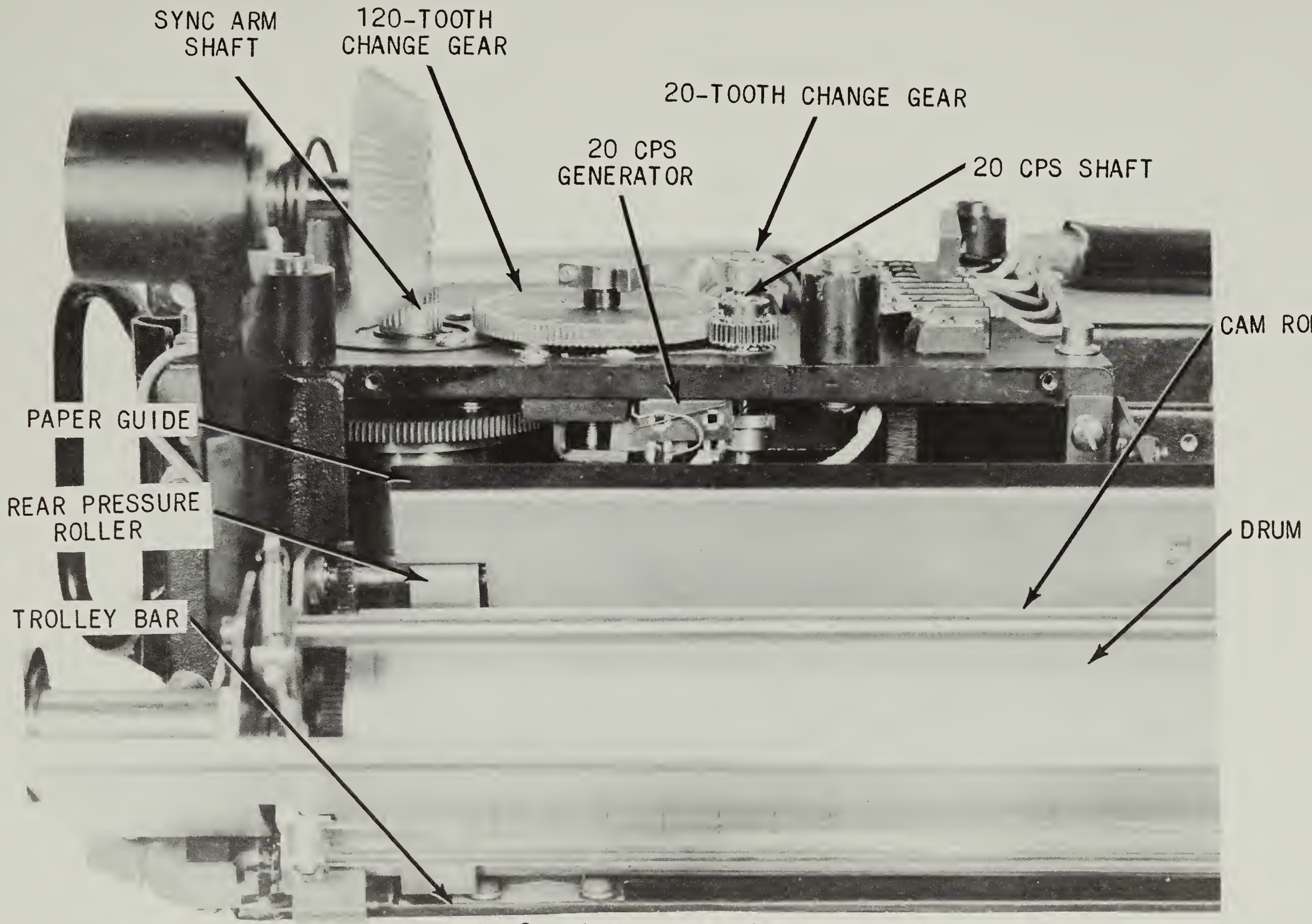


FIG. 9. SYNC GEAR BOX TOP VIEW

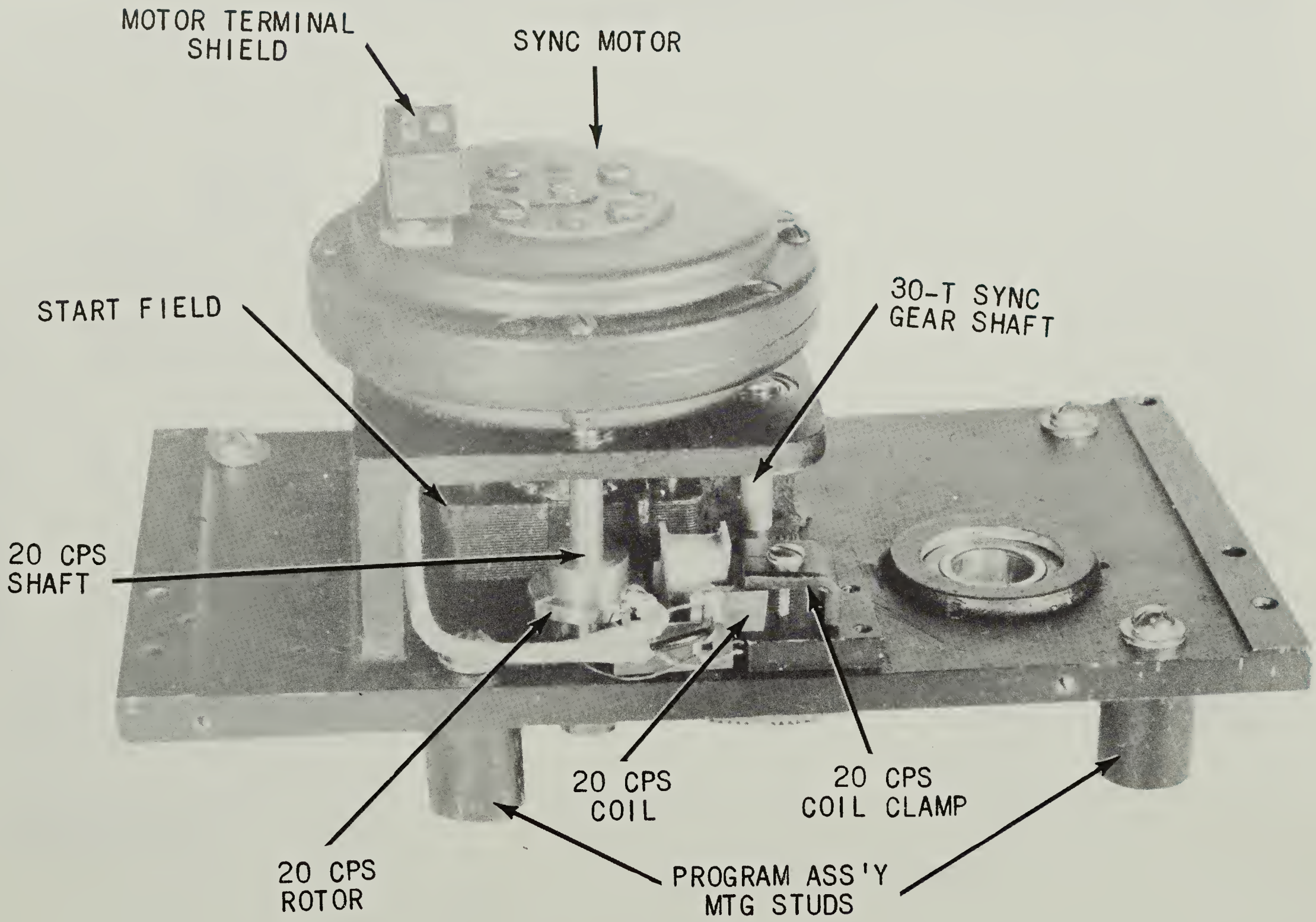


FIG. 10. SYNC GEAR BOX

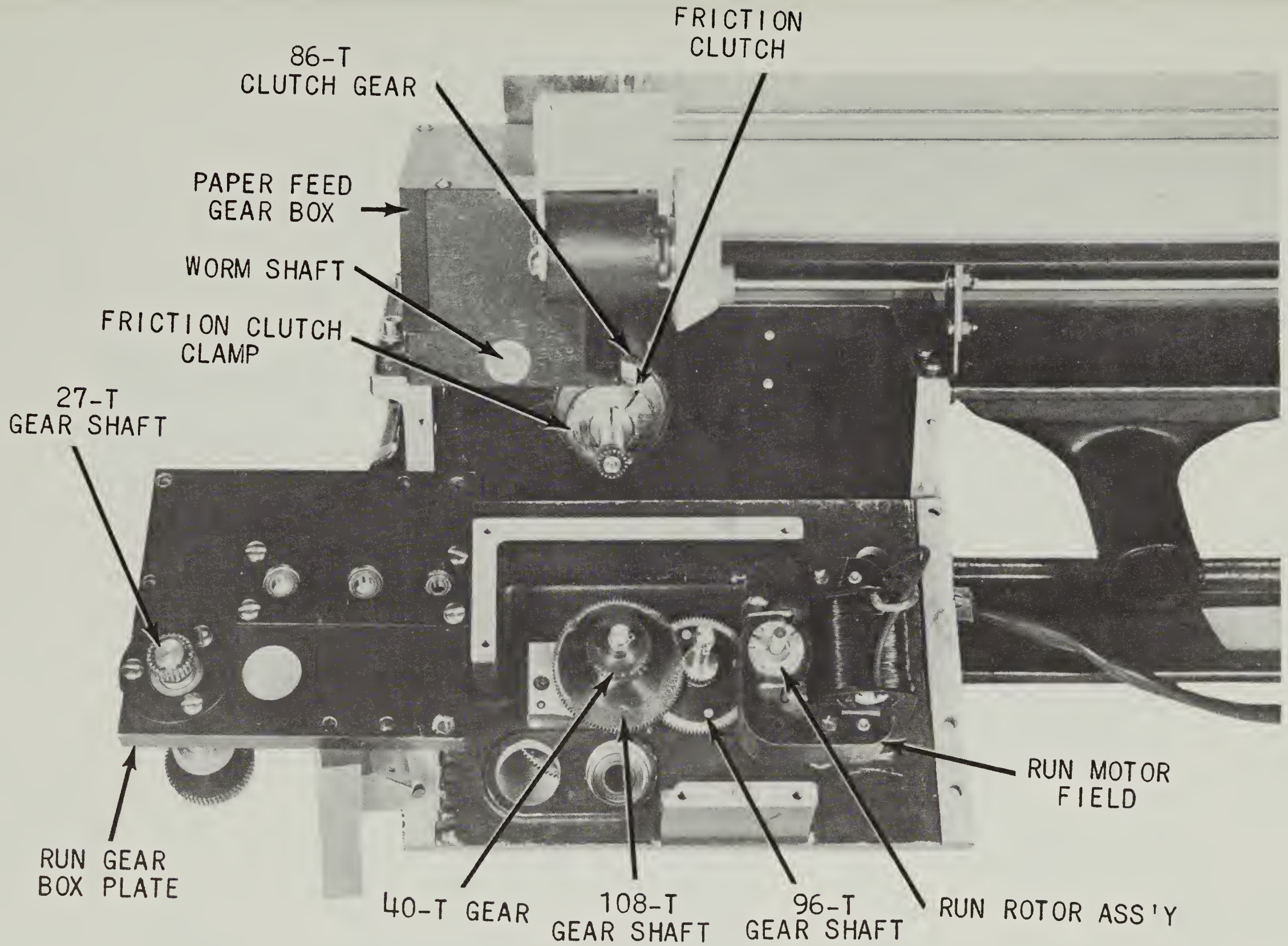


FIG. 11. RUN GEAR BOX

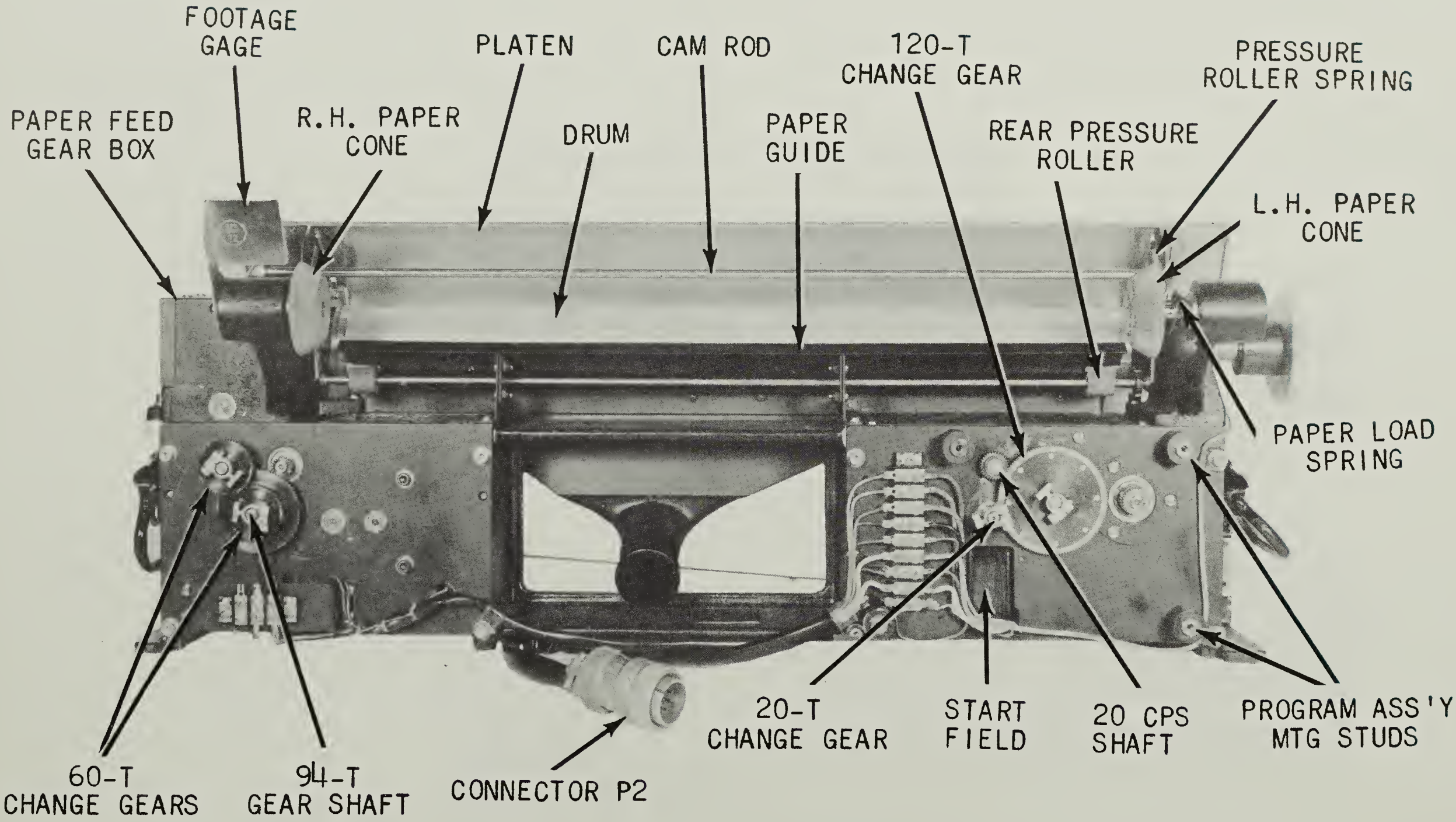


FIG. 12. MECH UNIT REAR VIEW WITH PROGRAM ASSEMBLY REMOVED

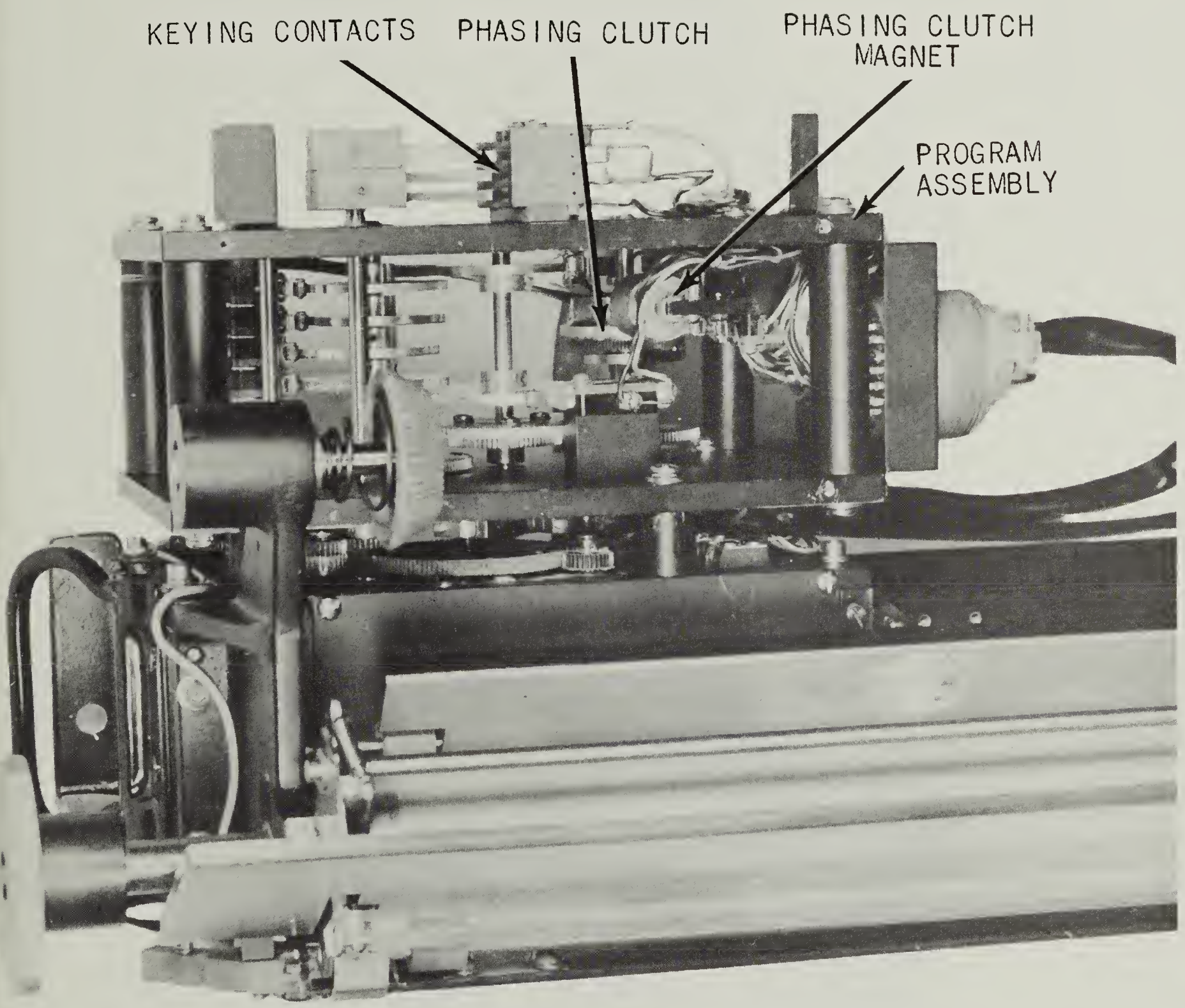


FIG. 13. PROGRAM ASSEMBLY IN PLACE

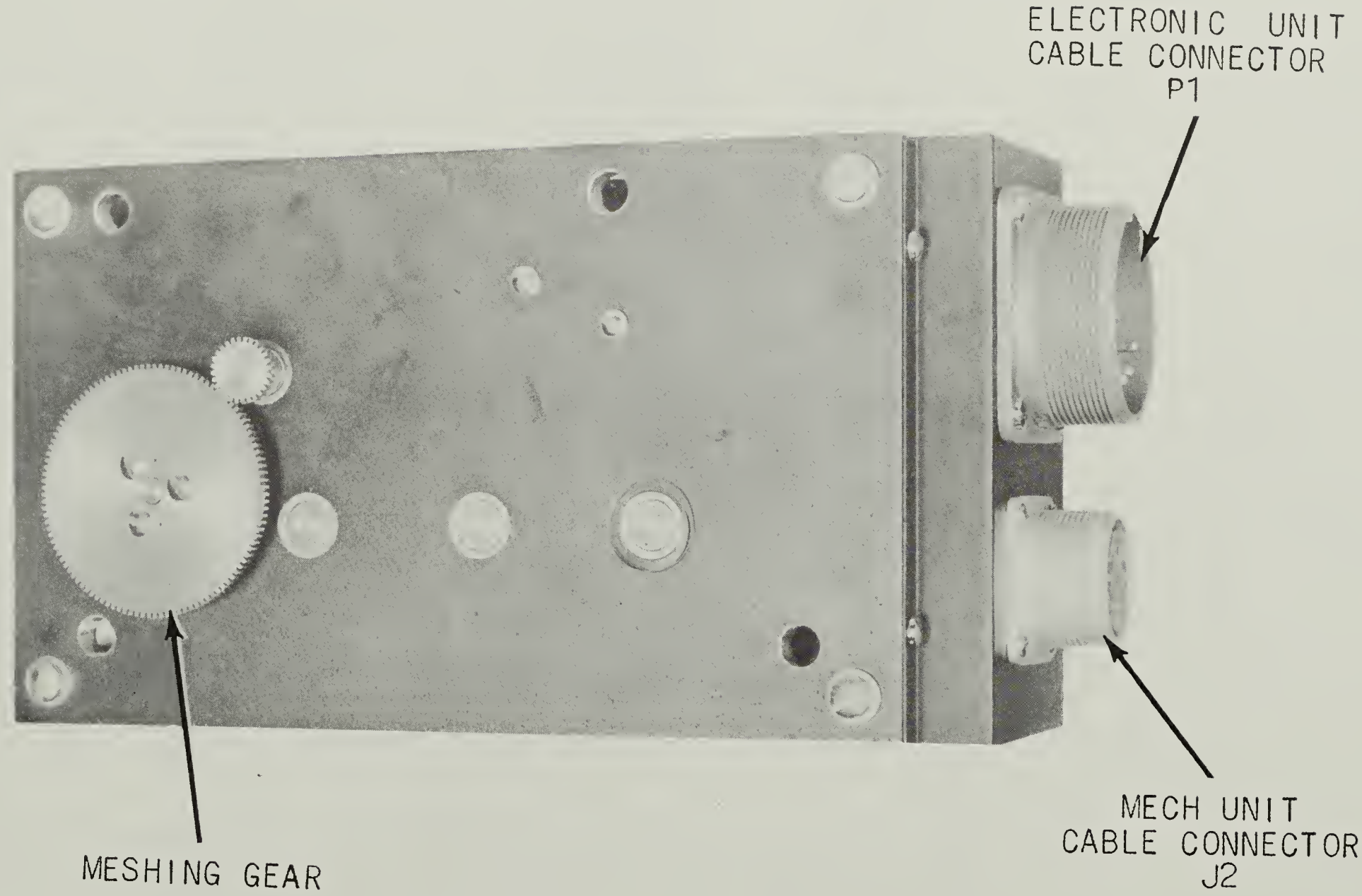


FIG. 14. PROGRAM ASSEMBLY FRONT VIEW

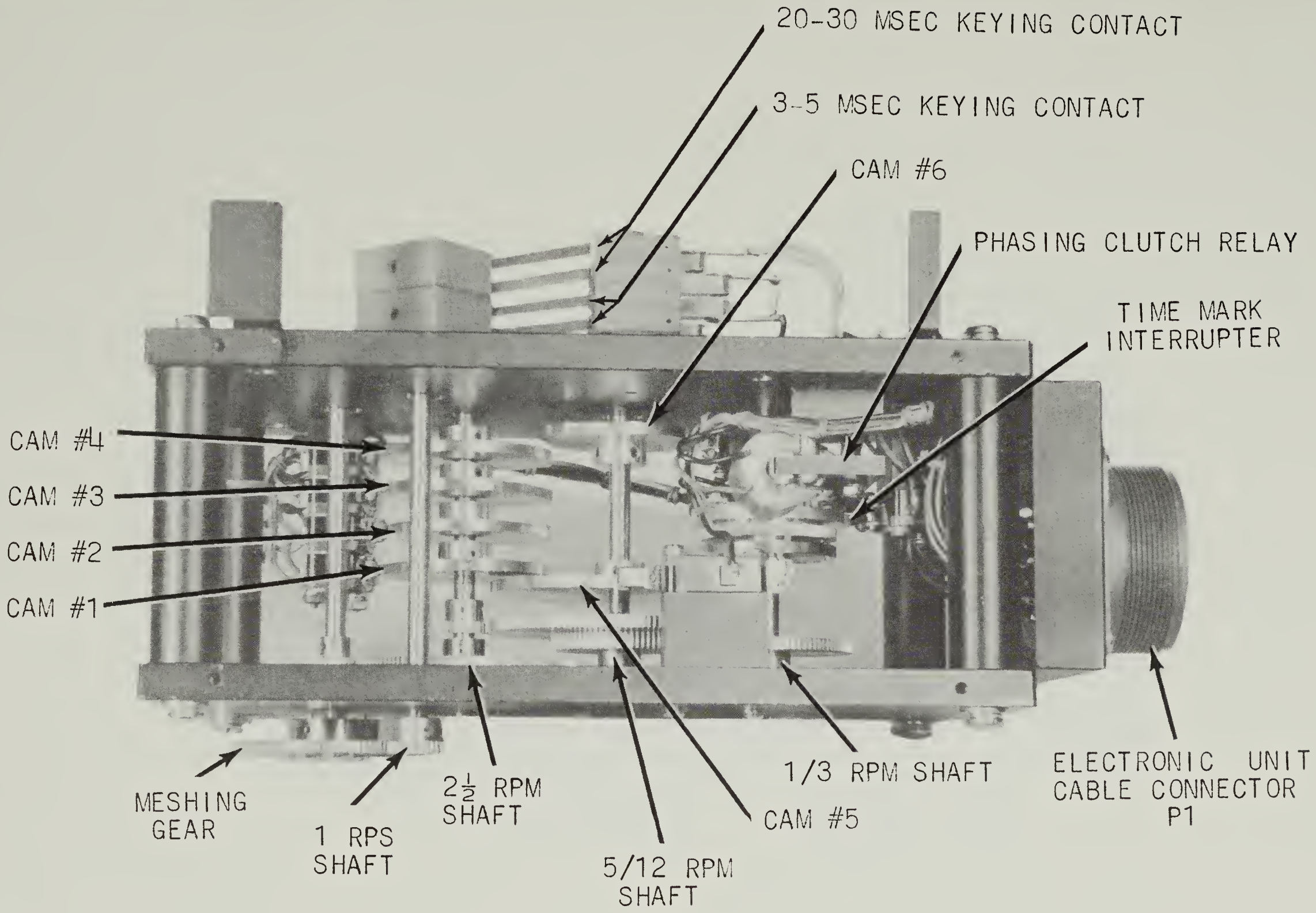


FIG. 15. PROGRAM ASSEMBLY TOP VIEW

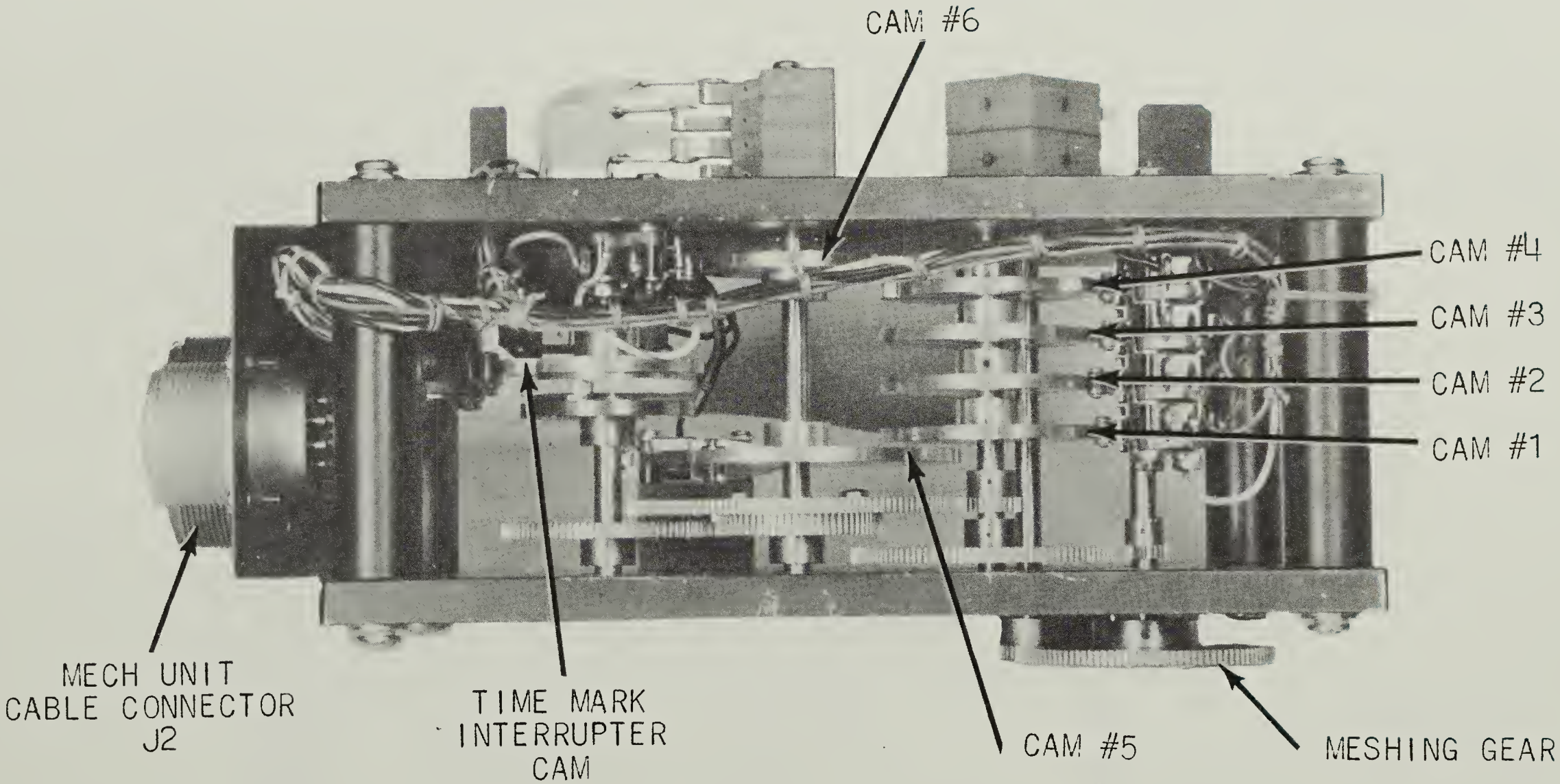


FIG. 16. PROGRAM ASSEMBLY BOTTOM VIEW

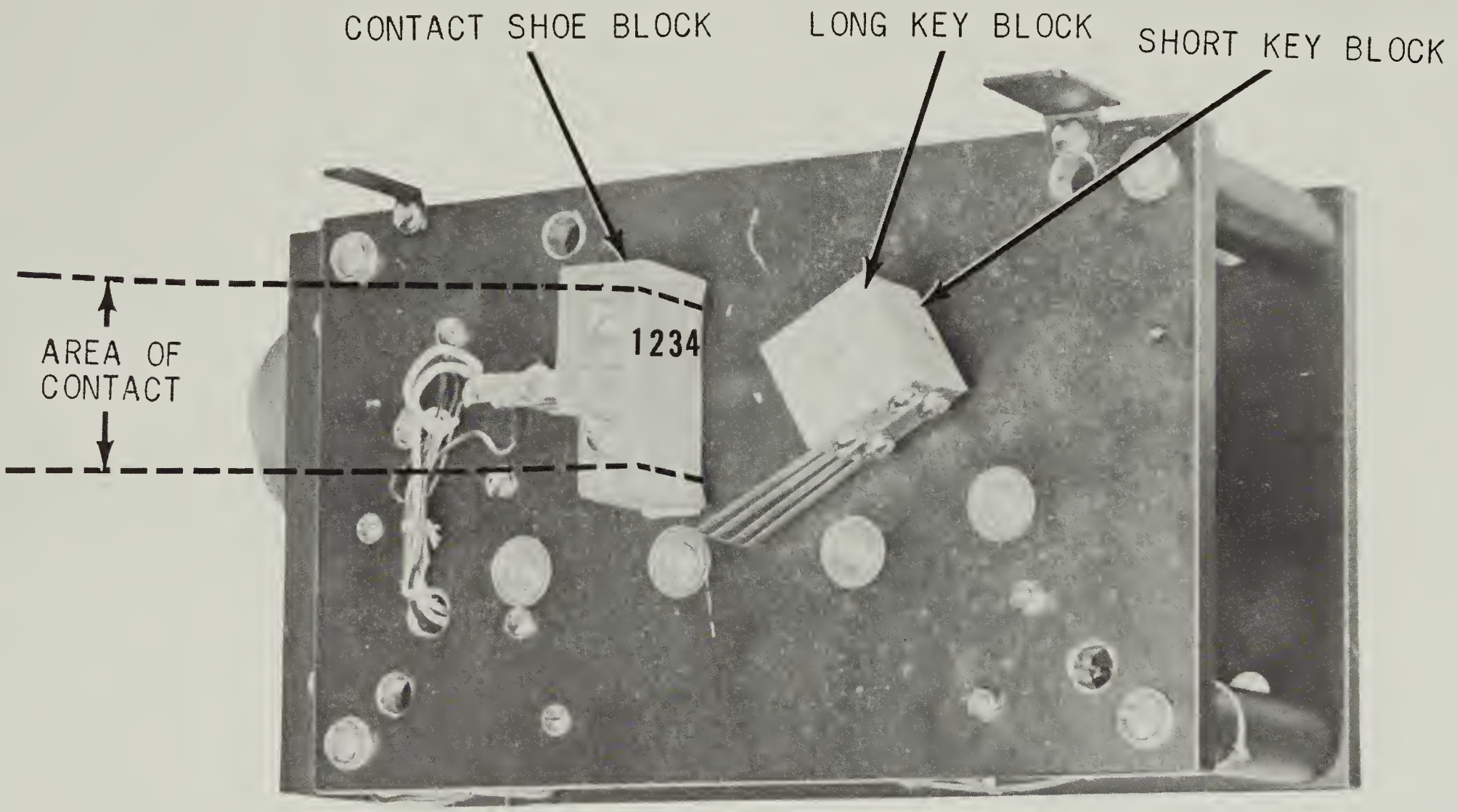


FIG. 17. PROGRAM ASSEMBLY REAR VIEW

through gearing to the latch mechanism which engages the SYNC MOTOR drive. After engagement, the band assembly is constrained to a precise speed of one scan per second. In order to avoid knocking the SYNC MOTOR out of synchronism (and thus stalling it), the RUN MOTOR drive includes a friction clutch which slips under the impact of the latch engagement.

c. Twenty Fathom Mark Generator

The SYNC MOTOR also drives the rotating cam armature of a 20-cycle pulse generator. This generator is of the variable reluctance type. The stator consists of a coil wound around a permanent magnet core. The magnetic flux path is completed by the rotating cam. Due to the variation of reluctance in the circuit, a voltage is induced in the coil whose wave shape closely approximates the physical developed shape of the cam. In this case, sharp pulses are generated which are printed as precise 20 fathom divisions of the 400 fathom record scale. A lucite bar, mounted on the front of the Mechanical Unit, has numbered graduations which serve as a guide in identifying the 20 fathom mark divisions.

d. Program Assembly

The auxiliary devices include the Keying Contacts, the Gating Cams, the Time Mark Interrupter and the Time Phasing Components. These are all contained in one Program Assembly which is completely detachable from the rest of the Mechanical Unit, (Figures 12 and 13). Mechanical connection is made to the RUN MOTOR through the Meshing Gear (Figure 14), and electrical connection to the Electronics Unit is made through P2-J2 and P1-J1.

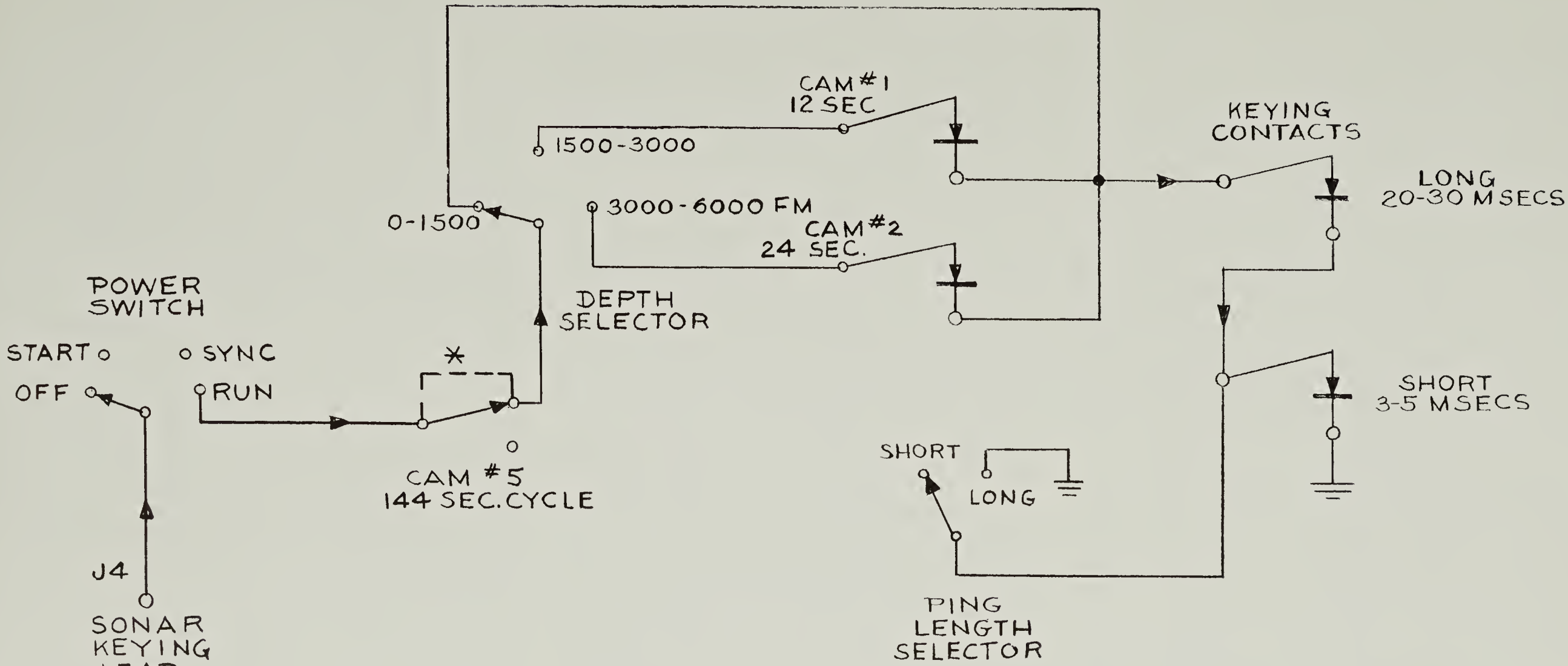
Refer to Figures 15 and 16, showing detailed views of the Program Assembly components and to Figure 24.

The Keying Contacts are driven by a shaft rotating at one revolution per second. The group of four Gating Cams, Nos. 1-4, for the expanded scale recorder program are driven by a shaft making one revolution in 24 seconds. Cams 5 and 6, the Slow Drum Gating Cams are driven by a shaft making one revolution in 144 seconds. The Time Mark Interrupter Cam and Clutch are on a shaft making one revolution in three minutes.

e. Keying Contacts

The Keying Contacts provide the ground connection required to key the Sonar Set Transmitter. Refer to Figure 17 which shows the Keying Contacts in detail and to Figure 24.

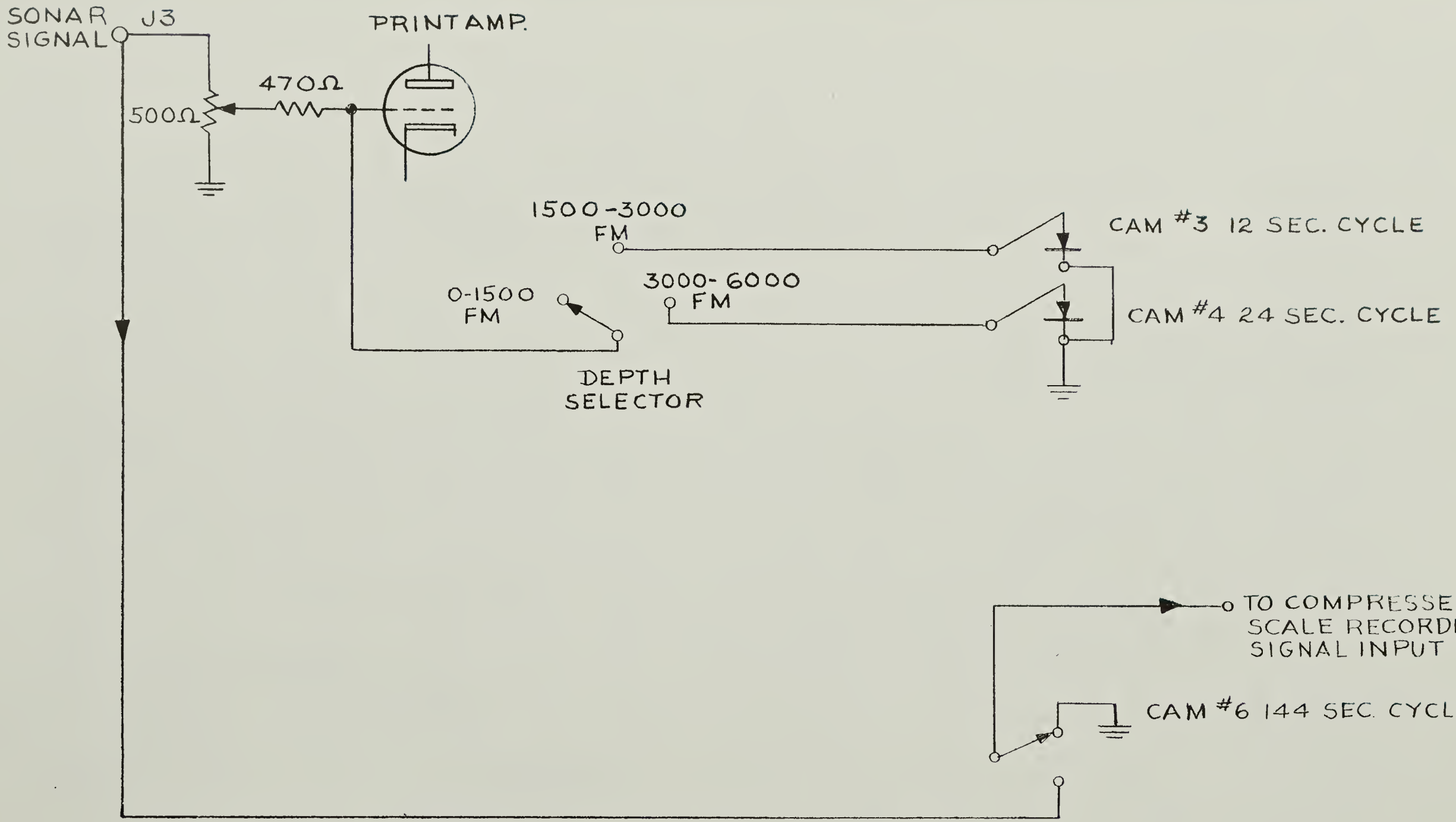
The Long Key Block carries a leaf-spring arm which connects contact shoes 1 and 2. The Short Key Block carries a leaf-spring arm which connects Contact Shoes 3 and 4. The width of the contact shoes is such as to make the duration of electrical contact 20-30 milliseconds. Contact 3-4 is connected in series with Contact 1-2. The Short Key Block is adjusted on the 1 RPS shaft in relation to the Long Key Block so that contact 3-4 breaks 3-5 milliseconds after Contact 1-2 makes. Thus Contact 3-4 determines the end of a short ping and Contact 1-2 determines the beginning



* REMOVE SHORTING JUMPER FOR COMPRESSED SCALE RECORDER OPERATION.

SIMPLIFIED SCHEMATIC
KEYING GATES
FIG. 18

PDR MK V



SIMPLIFIED SCHEMATIC
RECEIVING GATES

FIG. 19

of the short ping. Switch S6 on the Front Panel may be used to short out Contact 3-4. Then Contact 1-2 determines both the beginning and end of the long ping whose duration corresponds to the full width of the shoe contact, 20-30 milliseconds. The beginning of the keying pulse is synchronized with the beginning of the stylus scan by proper engagement of the Meshing Gear when the Program Assembly is mounted on the Mechanical Unit.

f. Keying Gate Cams

The Gating Cams provide the switching cycles which control the operation of the Keying Contacts, the Print Amplifier, and the Slow Drum Recorder. The proper gating cycle for the depth of operation is selected by the Depth Selector, S-2, on the Front Panel.

Refer to Figure 18, a simplified schematic of the keying circuit, and Figure 24.

The Sonar Keying Lead, which must be grounded to key the Sonar Set Transmitter, enters the PDR through J4. The Power Switch, S1-B, connects the Keying Lead to the circuit only in the RUN position so that if the Recorder happens to stop with the Keying Contacts grounding, the Transmitter will not be energized indefinitely, a condition which would cause component failures in the Sonar Set. The Keying connection is led from S2-B to the microswitch S11, controlled by Cam #5. This switch is shorted out unless a Slow Drum Recorder is being used. (Slow Drum operation is discussed below). The keying connection is now switched by Depth Selector S2-B. In the 0-1500 Fathom position, the Keying Lead is connected directly to the Keying Contacts so that the keying rate is one ping per second. In the 1500-3000 Fathom position, the Keying Lead is connected to the Keying Contacts through the microswitch S7, controlled by Cam # 1. This cam allows a keying rate of 6 pings, one second apart, every 12 seconds. In the 3000-6000 Fathom position, the Keying Lead is connected to the Keying Contacts through the microswitch S8, controlled by Cam #2. This cam allows a keying rate of 12 pings, one second apart, every 24 seconds. The Ping Length Selector Switch, S6, allows choice of the short (3-5 msecs) or long (20-30 msecs) ping duration as described above.

The Slow Drum Keying Program Cam, #5, operates on a 144 second cycle. This cam allows the cycle operation described above for 120 out of every 144 seconds, and controls the keying operation for 24 out of every 144 seconds. Only one ping, the one that would be the sixth in the 12 and 24 second cycles, is allowed to be transmitted during the 24 second Slow Drum period. This is necessary to prevent multiple bottom records being recorded on the Slow Drum and rendering the compressed scale record valueless.

g. Receiving Gate Cams

Refer to Figure 19, a simplified schematic of the signal input circuit, and Figure 24.

The Sonar signal input enters the PDR through J3. After passing through Gain Control, R201, and isolation resistor R202, the signal is connected to the grid of amplifier tube V201A and subsequently passes through the rest of the Print Amplifier to the stylus. Gating of the signal

is accomplished by grounding or not grounding the grid of V201A. This grid is connected to Depth Selector Switch S2-A. In the 0-1500 Fathom position, the grid is never grounded so that signal passes through the Print Amplifier continuously. In the 1500-3000 Fathom position, the grid is grounded through the microswitch S9, controlled by Cam #3. This cam is synchronized with the Keying Gate Cam #1 so that only the last 2 of the 6-ping group are recorded and signal is passed through in the last 8 1/2 seconds of every 12 second cycle. In the 3000-6000 Fathom position, the grid is grounded through the microswitch, S10, controlled by Cam #4. This cam is synchronized with the Keying Gate Cam #2 so that only the last 4 of the 12-ping group are recorded and signal is passed through in the last 16 1/2 seconds of every 24-second cycle.

The Sonar Signal is also led from J3 directly to the microswitch, S12, controlled by Cam #6. This cam controls the input to the Slow Drum Recorder. For most of its 144 second cycle, it grounds the Slow Drum signal input. It is synchronized with Cam #5 so that signal is passed through the Slow Drum Print Amplifier just in time to record the single ping of the Slow Drum 24-second recording period. The Slow Drum input is grounded again just before the end of this period.

h. Time Marks

Refer to Figures 15 and 16 and Figure 24.

The Time Mark Interrupter Cam operates on the 1/3 RPM shaft. It controls microswitch S5 which connects or disconnects the 20 cps generator pulses to the Fathom Mark Amplifier, V203B. The cycle is arranged to allow a 15 second interruption every three minutes. During this 15 second period, S5 shorts the generator coil to ground, interrupting the printing of the 20 Fathom lines on the record, and causing the Time Indicator Light on the Front Panel to extinguish. During the remainder of the three minute period, S5 completes the Time Indicator Light circuit and allows the 20 cps pulses to be printed.

i. Time Phasing

The Time Mark Interrupter Cam is driven by the 1/3 RPM shaft through the Phasing Clutch. The Phasing Clutch consists of a spring-loaded pawl and a ratchet wheel with an extended stop-arm. The stop-arm may be engaged by the armature of the Phasing Clutch Relay which is controlled by Time Phase Switch, S4 on the Front Panel. When S4 is in RELEASE position, the Phasing Clutch Relay is energized, the armature is lifted, and the Phasing Clutch is engaged. When S4 is in PHASE position, the Phasing Clutch Relay is de-energized, the armature drops and engages the extended stop-arm of the ratchet wheel when it comes around. With the ratchet wheel held, the pawl slips and the Time Mark Interrupter Cam stops moving. The Time Mark Interrupter Switch, S5, is adjusted so that it is now at the extreme end of the interruption period. If the Time Phase Switch, S4, is now snapped to RELEASE position, the clutch will engage and the 20 Fathom marks will immediately start printing on the record. If this last operation is synchronized with the Ship's time standard on some multiple of three minutes, the end of each interruption period (or the beginning of each 20 Fathom Mark printing period) will represent a three-minute time break in terms of Ship's time.

Note that since all the shafts in the Program Assembly are driven from RUN MOTOR gearing, when the RUN MOTOR stops, the Program Assembly ceases to function. Whenever the RUN MOTOR is stopped, e.g., when loading a new chart roll, the Time Phasing procedure must be followed again, since synchronization of the record time breaks with the Ship's time is lost.

(3) The Electronic Unit

The Electronic Unit contains all the circuitry required to control the operation of the PDR coupled to a Sonar Sounding Set. Connection to the Mechanical Unit is made through J1, a 23-terminal cable connector leaving the Electronic Unit from the top. General views of the Electronic Unit are shown in Figures 20 and 21. The complete circuit diagram is shown in Figure 24.

a. Power Supply

This circuit supplies unregulated B+ power at 300 volts DC, regulated B+ power at 150 volts DC, and filament power at 6.3 volts AC to the electronic circuits. It also supplies unregulated 20 volt DC power to the Phasing Clutch Relay circuit.

Single-phase, 115 V, 60 cps power enters the PDR through the line cord at the Rear Panel. Power fuse F1, rated at 3 amperes protects the circuits from overload and the neon pilot lamp indicates its failure. Power Switch S1-A connects line voltage across the primary of the Power Transformer, T101. The primary has three taps which may be selected by S3 on the Rear Panel for the appropriate line voltage. The secondary has a 6.3 volt winding for filament power and a 5 volt and high voltage winding which feed a conventional power supply circuit utilizing a choke-input filter. High voltage rectifier tube V101, a 5R4, and regulator tube, V102, a 0A2, were chosen because they are used in the AN/UQN-1B Sonar Sounding Set and therefore simplify the spare parts requirements. Fuse F2, rated at 1/4 ampere, protects the high voltage supply and has a neon indicator in parallel. The 20 volt DC supply for the Phasing Clutch Relay is tapped off the high voltage through R101.

b. Fork-Controlled Oscillator

This is a plug-in unit located at the rear of the Electronic Unit which generates an 1800-cycle signal for synchronous motor operation and for use as an Event Mark signal. The unit consists of an 1800-cycle tuning fork, whose output is amplified by three stages of amplification, with positive feedback to drive the fork.

The 1800-cycle fork has a pick-up coil which provides a signal to the first amplifier stage, V301A, and a drive coil which accepts a feedback signal from the power amplifier stage, V301B.

The 1800-cycle fork signal from the fork pick-up coil is applied through a shielded lead to the grid of the fork amplifier, V301A, a half section of a 6SN7. V301A is a class A amplifier with an unbypassed cathode resistor R311 to provide inverse feedback for this stage to stabilize the circuit. The amplified 1800-cycle signal is resistance-coupled through

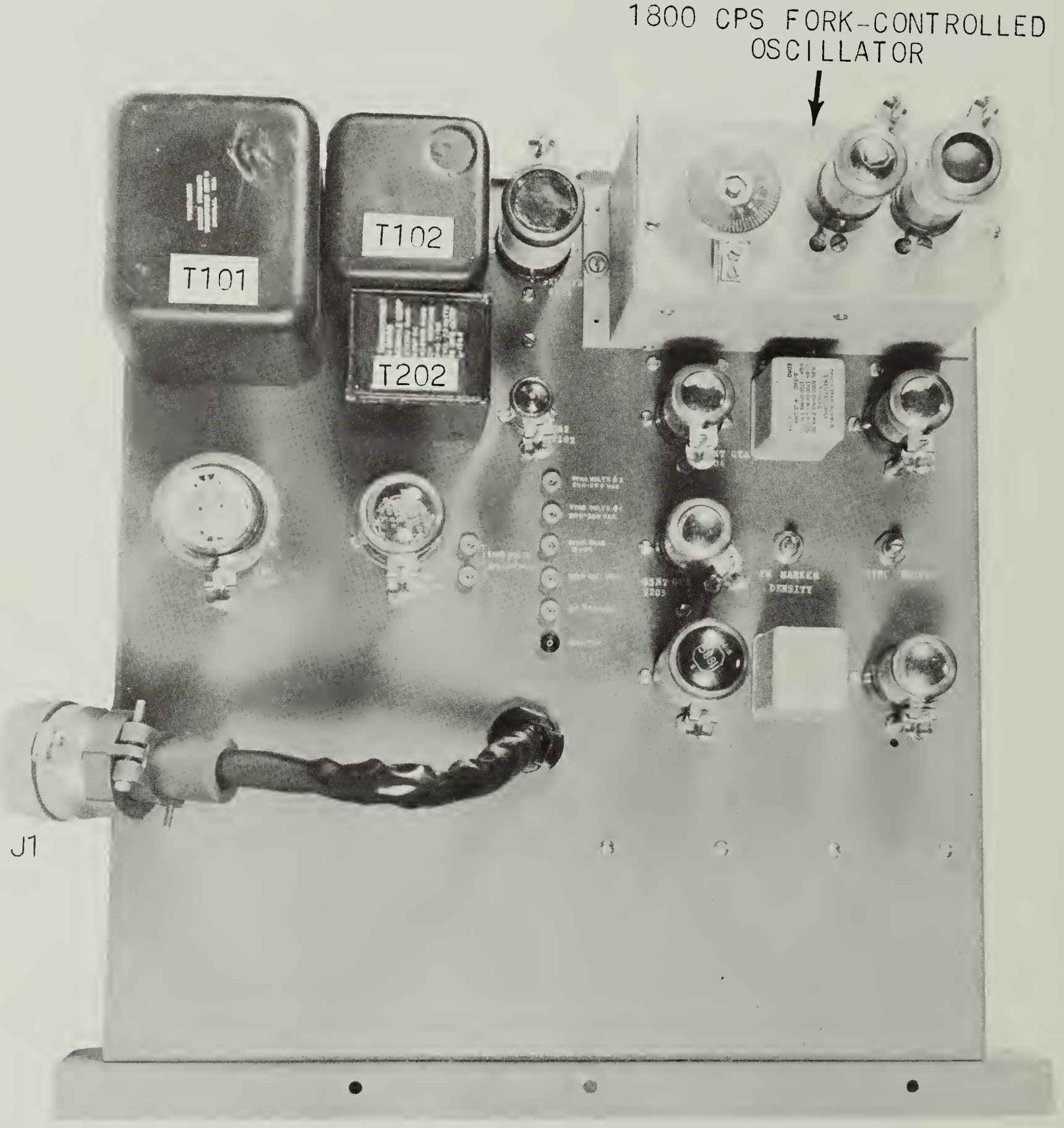


FIG. 20. ELECTRONIC UNIT TOP VIEW

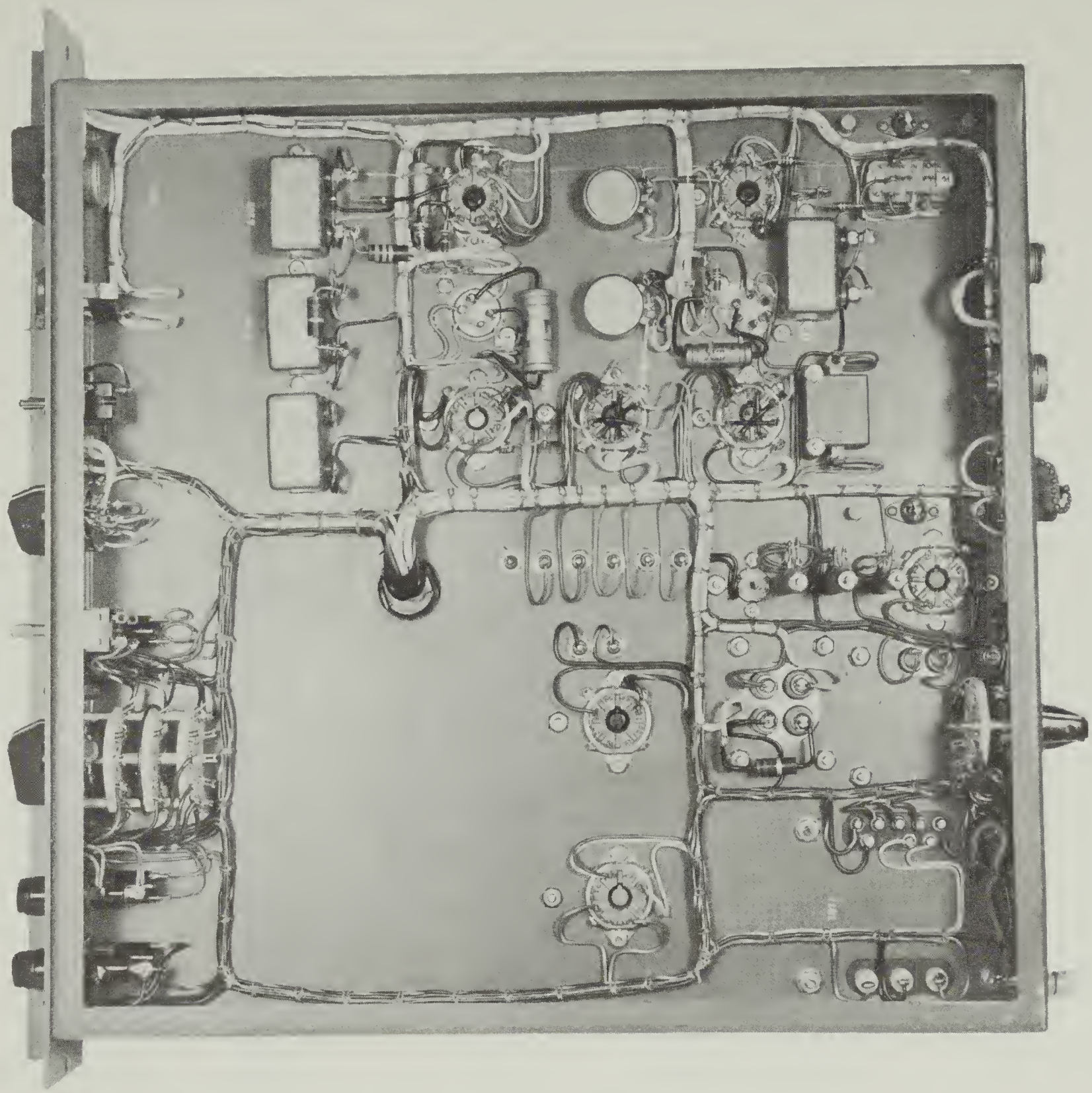


FIG. 21. ELECTRONIC UNIT BOTTOM VIEW

capacitor C302 to the control grid of V302, a 6AG7.

V302 is connected as a conventional pentode amplifier and operates as a fork limiter stage. Sufficient signal is delivered to the control grid of this stage to cause plate current limiting. This action results in a constant level output, regardless of the input signal received from V301A over the operating range of the fork.

The output of V302 is coupled through capacitor C304, R308 and R310 to the grid of V301B, which acts as a power amplifier feeding the drive coil of the fork. Resistors R308 and R309 form a voltage divider to reduce the input signal to V301B.

A variable wire-wound resistor, R312, in the cathode circuit of V301B controls the frequency of the fork oscillator. When this resistor is set at the minimum value, maximum signal is delivered to the fork drive coil. This causes the fork to vibrate at a frequency slightly lower than 1800 cycles. With R312 adjusted for maximum resistance, a minimum signal is applied to the fork drive coil and the fork vibrates at slightly more than 1800 cycles. The total range of amplitude variation on the fork drive coil is approximately 8 to 1. This results in a frequency variation of approximately plus or minus 0.04 cps from the tuning-fork center frequency of 1800 cycles.

The output from the fork-controlled oscillator is obtained from isolating resistor R307. This output feeds through P6-pin 6 to provide signal for the Sync Motor Amplifier circuit. P6-pin 3 connects the circuit return to B- (Chassis Ground) and Pin 4 connects the circuit plate supply to the decoupling filter, R216, C208, and the 150 volt DC regulated supply. Filament voltage is brought in to the plug-in unit through pins 10 and 15.

c. Sync Motor Amplifier

The motor amplifier comprises two stages: V203A, which serves as a buffer stage to isolate the fork oscillator from the motor power circuits and provides sufficient amplification to drive the power stage; and V204, V205, the motor amplifier tubes, which provide the power to operate the synchronous motor.

The 1800-cycle signal from the fork-oscillator unit connects to variable resistor R213 and then to the grid of the buffer motor-driver tube, V203A, one half section of a 6SN7. This stage is a transformer-coupled amplifier with an unbypassed cathode resistor, R214, to provide greater stability. R213 controls the amplification of this stage to provide the proper amount of driving power for the motor amplifier tubes V204 and V205.

The output of V203A is coupled through transformer T203 to the grids of the motor amplifier tubes, two 6SN7GTA'S connected in push-pull. These are operated as Class AB amplifiers, self-bias being supplied by cathode resistor R215 and bypass capacitor C205. The ground return of this stage is controlled by Power Switch S1-D which makes the ground connection in the SYNC and RUN position only. This is done to prevent SYNC motor power being applied until the START MOTOR has brought it up to speed.

The output of V203A is also coupled to the Slow Drum Sync Drive circuit through capacitor C209 and J5-P5, pin C. This provides precision 1800-cycle voltage to the slow drum and eliminates the need for another fork-oscillator unit.

The output of V203A is coupled to the Print Amplifier through C209, isolation resistor R12, and the Event Marker Switch. Operation of the Event Marker Switch, S6, on the Front Panel connects 1800-cycle voltage to the grid of V201B in the Print Amp. and causes a black line to appear across the width of the recording chart.

d. Print Amplifier

The Print Amplifier comprises three stages: V201A, which provides voltage amplification and serves as the gated tube for cycled operation; V201B which provides a recording threshold above the normal noise level and sufficient amplification to drive the power stage; and V202, which provides power to the recording stylus needle.

The 4000-cycle signal from the Sonar Set enters the Electronic Unit through J3-pin B. The ground connection is carried on J3-pin A. Earphone Jack J6 is connected across J3 to provide a monitoring point in place of the Sonar Set Earphone Output Jack used for transferring the signal to the PDR.

The 4000-cycle signal is connected from J3-pin B to R201, a variable resistor which serves as the Gain Control for the Print Amplifier, and then through isolation resistor R202 to the grid of V201A.

The signal is also connected from J3-pin B through J1-P1, pin P to S12, the Slow Drum Receiving Gate, a cam-operated switch in the Program Assembly. It is then connected through J1-P1, pin N. to the Slow Drum receptacle, J5, on the Rear Panel.

The grid of V201A connects to the Depth Selector Switch S2-A and thence to the receiving gate cam-operated switches in the Program Assembly. Gating is accomplished by grounding or not grounding this grid.

V201A, a one-half section of a 6SN7, is a class A voltage amplifier with cathode resistor R203 unbypassed to provide stability. The plate impedance is provided by R204 and the signal is coupled to the grid of V201B through capacitor C201 and resistor R205.

V201B, a one-half section of a 6SN7 is operated as a transformer-coupled amplifier normally biased to cut off. The cut-off bias, about 12 volts, is supplied by dropping resistor R206 and cathode resistor R207. The cut-off bias operation of this stage sets a recording threshold for the signal level and serves to eliminate low-level noise from accumulating on the record and using up the dynamic range of the recording paper.

When the Event Marker Switch, S6, is operated, 1800-cycle signal appears at the V201B grid at a high enough level to overcome the threshold bias.

The output of the Fathom Mark Amplifier, 20-cycle rectified pulses is fed to the plate of V201B and adds to the signal output of this stage.

All the signals at the output of V201B are coupled through transformer T201 to the grid of the power stage, V202, a 5881. This is operated as a Class A amplifier, self-bias being supplied by cathode resistor R208 and bypass capacitor C203.

The signal is coupled to the recording styli through output transformer T202; current-limiting resistor R209; J1-P1, pin J; J2-P2, pin B; and the Trolley Bar on the front of the Mechanical Unit. The ground return of the power stage is made through Power Switch S1-D in RUN position only. This is to prevent signal from causing holes to be burned through the recording paper when the styli are stationary.

Plate voltage for the power stage is +300 volts. Regulated +150 volts is supplied to the other two stages.

e. Fathom Mark Amplifier

This is a single stage amplifier which raises the level of the 20 Fathom Mark Generator output and feeds it to the Print Amplifier circuit.

The 20-cycle pulses are connected from the Mechanical Unit to the Electronic Unit through J1-P1, pin M. and appear across germanium rectifier CR1. The rectifier action eliminates the portion of the pulse with negative polarity with respect to ground from passing through the amplifier.

Variable resistor R211 controls the density of the 20 Fathom Marks appearing on the record and connects the pulse signals to the grid of V203B.

V203B, a one-half section of a 6SN7, is connected as a zero-bias voltage amplifier with plate load R210. The output of V203B is coupled to the plate of V201B through capacitor C204. Because of the rectifier action of CR1, the output of the Fathom Mark amplifier will add to the other signal output appearing at the plate of V201B.

f. Rear Panel

The Rear Panel of the Electronic Unit contains all the components required for interconnecting the PDR with the Sonar Sounding Set, with an auxiliary Slow Drum Recorder, the Blower and take-up motors, the AC Power line, and the Ship's ground.

Refer to Figure 22 and read from left to right. See Figure 24.

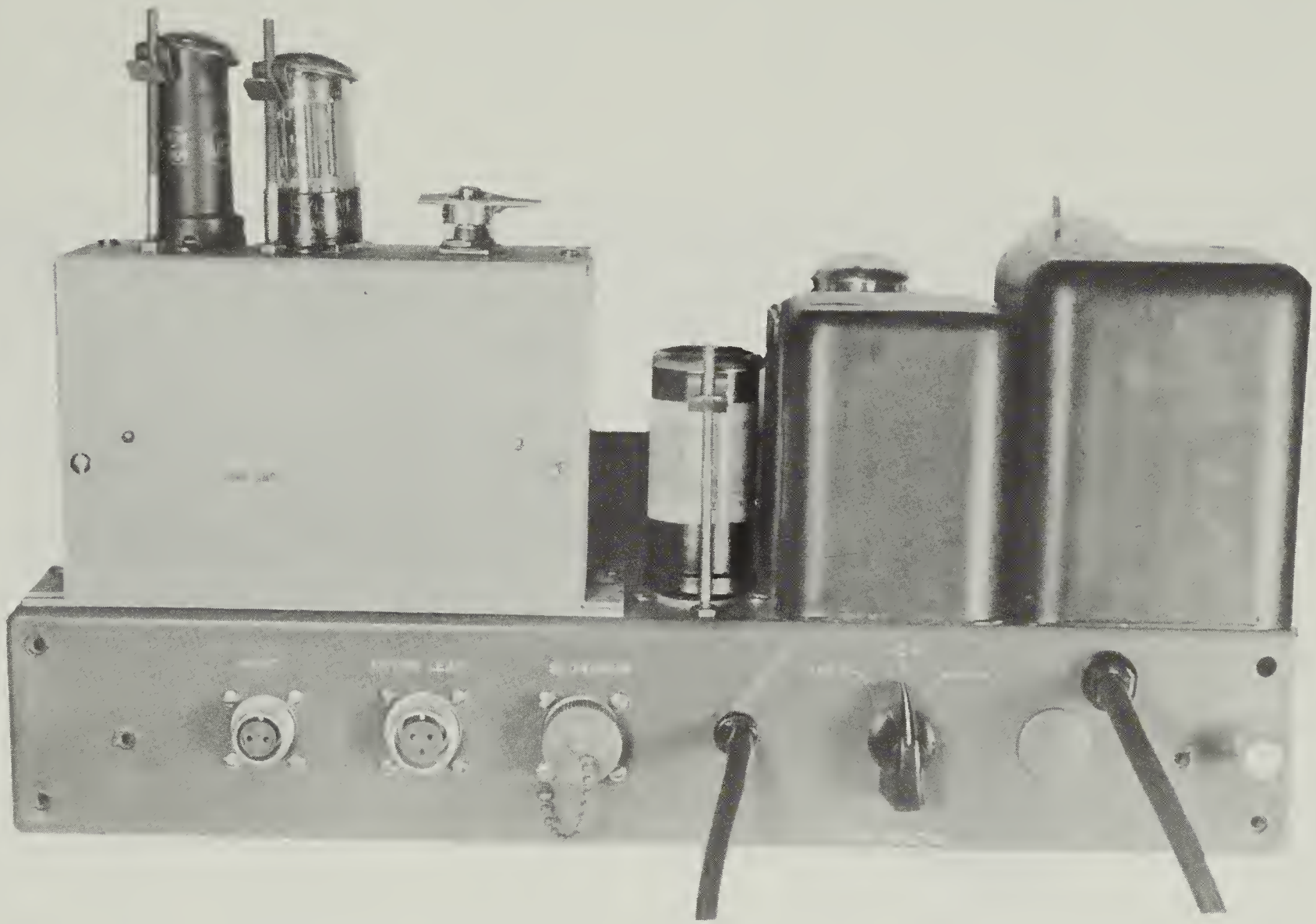


FIG. 22. ELECTRONIC UNIT REAR VIEW

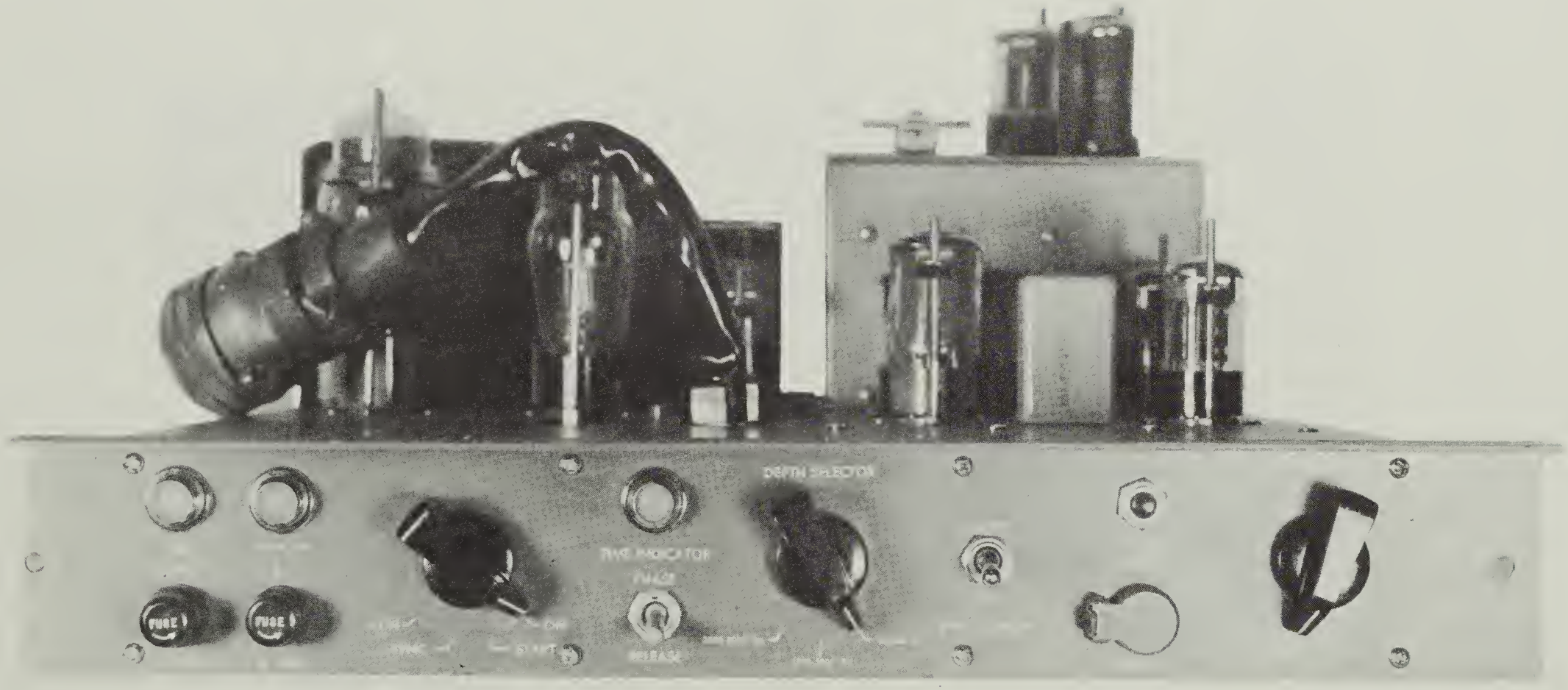


FIG. 23. ELECTRONIC UNIT FRONT VIEW

The two-terminal receptacle labeled INPUT is J3. The 4000-cycle signal from the Sonar Sounding Set is connected to Pin B. Pin A is ground.

The three-terminal receptacle labeled KEYING LEAD is J4. The Keying Lead from the Sonar Set is connected to pin B. Pin A is ground. Pin C is not used.

The four-terminal receptacle labeled SLOW DRUM is J5. Pin A is ground. Pin B is connected to the Gating Switch S12 and provides gated 4000-cycle signal voltage. Pin C is connected to the output of V203A through capacitor C209 and provides 35 volts of precision 1800-cycle frequency. Pin D is not used.

The cable leaving the center of the Rear Panel is terminated by two AC line receptacles. These carry line voltage to the Blower and Take-up motors when the Power Switch, S1-E is in RUN position.

The three-step selector switch labeled LINE VOLTAGE is S3. This switch selects the appropriate primary tap on transformer T101 for operation at AC line voltages of 105, 115, and 125 volts.

The cable leaving the Rear Panel at the right end of Figure 22 is terminated by an AC line plug. This cable carries 60-cycle AC power from the Ship's supply to the PDR.

The lug labeled GROUND is connected to the chassis ground of the PDR and the Power Supply B-. The Ship's ground is connected to this lug.

g. Front Panel

The Front Panel of the Electronic Unit contains all the components required to control and monitor the operation of the PDR.

Refer to Figure 23 and read from left to right. See Figure 24.

The fuse holder labeled 3 AMP contains the power line fuse F1. Above it is the neon pilot light indicator. This light goes on when the Power Switch is in any position except OFF. If the light extinguishes during normal operation, a blown fuse, F1, or a power line failure is indicated.

The fuse holder labeled 1/4 AMP contains the Power Supply fuse, F2. Above it is a neon indicator light which is connected in parallel with F2. If this light goes on, it indicates that F2 is blown.

The four-position selector switch with the steps labeled OFF, START, SYNC, RUN is the Power Switch, S1. This switch is a 6-pole 4-position shorting-type. It controls the application of AC line power to the Power Supply and the Start, Run, Blower and Take-up motors. It also completes the circuits of the Sync Motor Amplifier, the Print Amplifier and the Keying Leads.

The TIME INDICATOR neon light is controlled by switch S5 in the Time Mark Interrupter circuit. When the light is on, 20 Fathom Marks are being printed on the record. When the light is off, the marks are interrupted.

The PHASE RELEASE switch below this light is S4. This switch controls the Phasing Clutch Relay power. In RELEASE position, the relay is energized and the Time Mark circuit operates normally. In PHASE position, the relay is de-energized, and the Time Mark circuit ceases to operate at the end of the next interruption period. Operation of this switch enables the PDR time marks to be synchronized with the Ship's Time Standard.

The DEPTH SELECTOR switch is S2, a 2-pole 3-position type. It is used to select the programmed gating cycle appropriate to the depth of water over which the Ship is operating. The 3 depth ranges are 0-1500, 1500-3000, and 3000-6000 FATHOMS.

The PING LENGTH switch, S6, selects one of two possible durations of the transmitted Sonar pulses. The LONG pulse is 20-30 milliseconds in duration. The SHORT pulse is 3-5 milliseconds long.

The EVENT MARKER is a push-button switch, S6, which connects 1800-cycle voltage to the Print Amplifier and causes a black line to be printed across the width of the record. These lines, in conjunction with the time-break marks, indicate the time of occurrence of events of interest in the sounding operation.

The PHONES jack, J6, is available as an audio monitoring point for the signal coming into the PDR from the Sonar Set.

The GAIN control varies potentiometer R201 and controls the density of recording of the Sonar signal.

h. Test Points

Refer to Figures 20 and 24. Eight pin jacks are provided at the top center of the Electronics Unit for checking the AC line voltage, the SYNC Motor Amplifier circuit and the Power Supply.

SECTION THREE

INSTALLATION

I. UNPACKING

The equipment, including equipment spares, is packed in two cases. The large case, weighing approximately 136 pounds, contains the cabinet and electrical chassis. The small case, weighing 67 pounds, contains the mechanical unit. Both cases should be kept in the upright position; i.e., with the solid wooden skid on the bottom. The paper supply is packed in a cardboard carton.

Take care when unpacking or handling the equipment. It may be damaged when not protected by the packing case. When unpacking, be careful to avoid damaging the packaging materials more than absolutely necessary. Store the inside packaging materials in the shipping container for futureuse.

When uncrating the equipment, use the following procedure:

(1) Cut the steel straps with a suitable cutting device or twist with pliers until the straps tstallize and break.

(2) Turn the cases on end and remove the four screws fastening the sides to the wooden straps on the skid.

(3) Place the cases right side up and remove the screws that fasten the sides to the skid.

(4) Carefully lift off the top and sides of the cases.

NOTE: The top should not be disassembled from the sides of the case.

(5) Inspect the contents of the large case, noting that:

(a) The spare stylus band assembly is not damaged. Check the stylus leaf springs and pressure springs for breaks. Check that the band has not been crimped.

(b) The electrical chassis is not damaged. Check for broken tubes, control knobs, etc.

(c) The cabinet doors open and close properly.

(6) Inspect the contents of the small case, containing the mechanical unit, noting that the stylus band assembly is not damaged.

(7) To remove the cabinet from its skid, unscrew the nuts from the bolts located near the corners of the cabinet. Lift up the skid,and push the bolts out of the wooden clamps. Slide the clamps out of the hand grips.

(8) Lift the cabinet off the skid.

(9) To free the mechanical unit, remove the nuts from the four mounting bolts and lift mechanical unit off the skid.

(10) If space is available, store the cases for future use.

II. SELECTION OF SITE

The following factors should be considered when selecting the permanent site for the Precision Depth Recorder.

A. WEIGHT

Be sure that the platform or table is capable of supporting the weight of the equipment, 140 pounds.

B. SPACE

Enough clearances should be provided to assure ease in operation and maintenance. The cabinet dimensions are 29 1/4 inches long, 17 inches high, and 21 3/4 inches wide. At least five inches clearance must be allowed between the rear of the cabinet and the nearest bulkhead. At least 20 inches overhead clearance must be allowed for the top cabinet door to open.

C. VENTILATION

Proper ventilation must be available otherwise the carbon particles and fumes generated by the recording process may cause the operator serious discomfort.

D. POSITION

The recorder should be placed in position close to the Sonar Sounding Set to which it is connected.

III. INSTALLATION

After unpacking, the PDR should be assembled and installed as follows:

(1) Move the recorder cabinet over to the installation site selected after considering the requirements mentioned in II above.

(2) Secure the cabinet by bolting through the mounting platform into the threaded holes of the four shock mounts.

(3) Lift up the cabinet cover.

(4) Remove the four screws projecting from the brackets on either side of the electrical chassis. These screws mount the mechanical unit.

(5) With the wheels facing toward the front of the cabinet, carefully set the mechanical unit upon the brackets.

(6) Line up the holes in the base casting with the threaded holes in the brackets. Insert the screws for preliminary line-up.

(7) Carefully close the cabinet cover. Check to see that the chrome platen lines up with the cutout in the cover. The platen should be flush with or slightly above the outside surface of the cabinet cover. There should be no interference between the cover and the paper advance wheel. If necessary, adjust the position of the mechanical unit so that the conditions stated are satisfied before tightening the four mounting screws.

(8) Turn the Power Switch to OFF position.

(9) Connect the Mechanical and Electrical Units by engaging P1-J1.

(10) Connect the exhaust hose from the exhaust motor to the Mechanical Unit exhaust connection by twisting the hose into the nozzle until secure.

(11) Connect the power cable into a 60-cycle 100-130 volt, single-phase line. The PDR power consumption is 215 watts. If the line voltage is known, adjust the line voltage switch, S3, on the Rear Panel to the corresponding tap.

(12) Two cables must be prepared for connection to the Sonar Sounding Set AN/UQN-1B.

The Signal Cable is a shielded lead terminated by plug P3 at one end and by a standard phone plug at the other end. P3 is plugged into J3 on the Rear Panel and the phone plug is plugged into the EARPHONES jack on the Sonar Set.

The Keying Cable is a shielded lead terminated by plug P4 at one end, and connected internally to the Keying Lead in the Sonar Set. The Keying Lead must be disconnected from the Sonar Set keying circuit.

P3 and P4 are supplied with the PDR equipment.

(13) Several changes are required in the Sonar Sounding Set wiring. These are described in SECTION TWO, paragraph II-A.

When these circuit changes and cabling connections are made, the installation of the Precision Depth Recorder is complete.

SECTION FOUR

OPERATION

I. INTRODUCTION

The operator must keep in mind that the Precision Depth Recorder only replaces the Recorder Unit of the Sonar Sounding Set. A transmitter, receiver, and transducer in good working order are required.

In the instructions which follow, it is assumed that the installation of the PDR has been made properly according to the directions in SECTION THREE. Furthermore, it is assumed that all the operating controls of the Sonar Set which are normally used for recording have been properly manipulated.

Refer to Figure 4-1 in Reference C showing the Sonar Set operating controls:

(1) The Power Switch should be ON.

(2) The Range Switch should be in a RECORDER position, - 600 Feet, 600 Fathoms, or 6000 Fathoms.

(3) The Ping Switch should be on AUTOMATIC.

II. OPERATING PROCEDURES

A. STARTING THE EQUIPMENT

The PDR is started by means of the Power Switch on the Front Panel.

(1) Switch to Start -- Wait 30 seconds.

(2) Switch to Sync -- Wait for motor to fall into Sync Speed. This is distinguished by the Steady High-Pitched Tone.

(3) Switch to Run.

B. SETTING THE GAIN

The signal gain is controlled at two places: on the front panel of the Sounding Set and on the front panel of the PDR. The principles to follow in setting the overall gain are as follows:

(1) The overall gain shouldbe as low as is consistent with obtaining a clear record.

(2) The Sonar Set Gain control should always be set as low as possible. If overall gain is to be lowered, use this gain control.

(3) The PDR gain control should be operated only after the Sonar Set gain control has been set at the lowest possible value consistent with obtaining a clear record. Use this control to raise the overall gain.

C. DEPTH SELECTOR

This switch should be left in the 0-1500 FATHOM position at all times unless the noise interference is too great in water deeper than 1500 Fathoms. Under noisy conditions, switch to the position appropriate to the operating depth range.

D. PING LENGTH

This switch should be left in the SHORT position at all times unless the noise interference is too great. Under noisy conditions, switch to LONG position.

E. EVENT MARKER

This button-switch should be depressed for at least one second duration to produce a black marker line across the record sheet. These marker lines, in conjunction with the record time break marks, serve to log in the time of occurrence of events of interest in the sounding operation. For example, events which are usually logged in on the echo sounding record in this manner are changes in Ship's speed or course. The Event Marker may also be used to identify the 3-minute mark on the record which corresponds to an integral hour or half-hour.

F. TIME MARK PHASING

In order to synchronize the time breaks on the record with the Ship's time standard (chronometer or WWV), use the following procedure:

(1) Place the Time Phase Switch on the front panel in PHASE.

(2) Wait until at least 15 seconds after the Time Indicator Light has gone out before doing anything else. (The total waiting period may be anywhere from 15 seconds to 3 minutes).

(3) Observe the Ship's time standard either visually, aurally, or by proxy, and wait until it reaches a time which is an exact multiple of 3 minutes.

(4) Snap the switch to RELEASE as closely as possible in phase with the time standard.

(5) The end of the 20 Fathom Mark interruptions is the time break. The beginning of the 20 Fathom Mark printing is the time break.

(6) The time breaks will remain synchronized, once set, as long as the PDR is in RUN operation. Whenever the Power Switch is turned back from RUN position, when loading a new paper roll, for example, the time marks must be rephased.

G. BASE LINE DETERMINATION

The operator must determine the value of the base line. This line,

made by the recording of the transmitted pings, represents some multiple of 400 fathoms of depth. The operator must maintain a record of the base line value on the chart itself or in a separate log. Several methods are suggested:

(1) Correlate the Ship's position with the charted hydrographic information.

(2) Start from a known base line (as in port) and mark the record each time it goes off scale.

(3) Listen with earphones at the monitor jack and count seconds between the transmission and reception of the last ping of a group (Gated Operation). In HDR operation (0-1500 Fathoms), the Ping Switch on the Sonar Set may be used to stop keying until the last ping has been timed.

(4) Switch back, for a short time, to normal operation on the 6000 fathom scale of the Sonar Sounding Set. This method requires that the switching arrangements be available.

SECTION FIVE

OPERATOR'S MAINTENANCE

I. INTRODUCTION

The operator should be sufficiently familiar with the details of the Precision Depth Recorder to service minor defects without technical assistancce.

II. MAINTENAICE PROCEDURES

A. LOADING PAPER ROLL

The paper is loaded with the recording system stopped. Turn the power switch back to SYNC to stop and to RUN when ready to start recording again.

(1) Lift Hood Cover and remove old core.

(2) Trim paper edge with a diagonal cut. Hold paper with top unrolling toward front of recorder.

(3) Load new roll by centering core on left-hand cone and pushing to left until right-hand cone engages into core hole.

(4) Remove any stylus needle that may be contacting the drum. (SEE INSTRUCTIONS FOR CHANGING STYLUS.) Par. II-C below.

(5) Set paper load lever in LOAD position and place leading edge of paper in chute between drum and rear rollers.

(6) Revolve PAPER ADVANCE wheel until paper exits out past lucite paper cutter.

(7) Lower paper load lever to neutral position (where front rollers are just off drum) and pull on end of paper to remove any wrinkles or creases that may have formed.

NOTE: Check that left-hand paper edge is safely behind right hand edge of stylus deflector. If not, styli may be damaged and paper torn.

(8) Lower paper load lever to RUN position.

(9) Reinsert styli.

(10) Restore all covers and advance paper a few inches beyond the chrome platen.

B. LOADING TAKE-UP REEL

(1) Load the paper through the machine per instructions. If

leading edge of paper is not square, tear it square now by pulling it smoothly over lucite cutter.

(2) Load empty paper core onto place on take-up Reel by pushing core onto left spring-loaded cone and snapping paper core into place on right cone.

(3) Pull paper gently up to and under core; bring free end around core and firmly tuck into place. Roll core a few times to clinch paper in place.

(4) Revolve knob on left side of Take-Up Reel for manual advance.

C. CHANGING STYLUS

(1) Switch to SYNC.

(2) Revolve wheels clockwise until stylus holder is at nine o'clock on the left wheel.

(3) Lift spring wire carefully out of slot and remove stylus with a rotating movement.

(4) Install new stylus with a rotating movement.

NOTE: Flattened end of stylus must be away from wheel center.

(5) Carefully replace spring wire into slot.

D. KEYING CONTACTS

The Keying Contacts should be inspected at least once per week. If carbon particles or other foreign matter has accumulated on the contact shoe block, (see Figure 17), wipe it with a clean, dry cloth. Be careful not to bend the leaf springs.

It is convenient to inspect the Keying Contacts when the paper roll is being renewed each week as the recording system is stopped and the hood cover raised for the paper loading operation.

III. ROUTINE CHECK LIST

As an aid in obtaining reliable and uninterrupted performance, the following items should be routinely checked at each change of watch:

(1) Log Information. This includes the Base Line Reference, identification of the Time Marks, and details of the Ship's maneuvers.

(2) Paper Supply. The amount of paper left on the roll may be checked by reference to the footage guide mounted next to the right hand paper support cone. (See Figure 3).

A roll contains 350 feet of chart paper which lasts about one week when expended at the rate of 2 ft./hr. Replace the roll when six feet or less of chart is left on the roll. Notice of the approach of the end of the roll is printed on the chart paper. The paper supply in stock should also be checked.

(3) Stylus Needle. If the needle length is less than 1/32 inches, or the record is spotty, replace the stylus needle.

A stylus needle ordinarily lasts at least 200 hours in continuous operation. The stylus stock supply should be checked.

(4) Gain Setting. See that the lowest gain setting consistent with a clear record is being used. If the gain requires lowering, use the Sonar Set control. If the gain requires raising, use the PDR control.

SECTION SIX

TROUBLE SHOOTING, ADJUSTMENTS AND REPAIR

I. GENERAL

No matter how well equipment is designed and manufactured, faults will always occur under service conditions. When such faults occur, repairmen must be able to locate and correct them as rapidly as possible.

However, it should be borne in mind that not all cases of trouble are caused by a defect in the equipment. The operator may fail to perform a required function at the proper time and report a case of trouble not realizing the true nature of the difficulty. Erratic operation of the PDR also may be caused by interference from other equipment. The following paragraphs describe the more common remedies and adjustments required by the PDR equipment. For details of other adjustments, e.g. replacing sync motor, consult Reference D.

II. TROUBLE SHOOTING BY THE OPERATOR

Before calling in a serviceman, the operator should make the following checks:

A. FAILURE TO START

If the Start Motor does not turn in START position, check the pilot lamp above the 3 ampere fuse on the front panel. If the light is out, either the fuse is blown, the AC line plug is disconnected, or the Ship's AC supply has failed.

B. FAILURE TO SYNC

If the Sync Motor attempts to, but does not fall into synchronism in SYNC position, turn back to START, wait 30 seconds and try again. If several attempts fail, call in the serviceman.

C. PAPER FEED FAILURE

If the chart paper does not feed properly, make sure that all instructions for loading paper (Section FIVE, Par. II-A) have been followed. Especially check to see that Paper Load Lever is in RUN position.

If necessary, remove roll, and load over, carefully following loading instructions.

D. STYLI NOT PRINTING

If the ping signals are not printing on the record, check the condition of the styli first and then make sure that all the operating instructions in SECTION FOUR have been followed.

Especially check to see that all the Sonar Set controls are in correct position. (See Section Four, Par. I).

E. CONTINUOUS PING

If the transmitter appears to be keying continuously, SHUT DOWN THE SONAR SET IMMEDIATELY OR SERIOUS DAMAGE MAY RESULT.

III. TROUBLE SHOOTING PROCEDURES

A. GENERAL

(1) In case of trouble, the first step in the correction procedure is the isolation of the trouble between the PDR and the Sonar Sounding Set.

(2) If the trouble is in the Sonar Set, follow the trouble-shooting procedures in Reference C.

(3) If the trouble is in the PDR, the first step in the correction procedure is the isolation of the trouble between the Mechanical Unit and the Electronic Unit.

(4) Mechanical difficulties must be corrected before electrical adjustments are made.

B. ISOLATION PROCEDURE

In case of loss of signal, disconnect the keying lead plug, J4, at the rear of the PDR. Connect the crystal earphones supplied with the Sonar Sounding Set AN/UQN-1B to the Earphone jack, J6. The Sonar Set may now be checked for proper operation by momentarily shorting pins A and B in J4, which should key the Sonar Transmitter, and monitoring the output with the earphones.

NOTE: BE CAREFUL NOT TO ALLOW MORE THAN A MOMENTARY SHORT BETWEEN PINS A AND B. CONTINUOUS KEYING OF THE SONAR TRANSMITTER WILL CAUSE SERIOUS DAMAGE.

If the Sonar Set is keying and receiving properly, trouble is indicated in the PDR. The more common failures are listed below.

Use the test turret socket for measuring tube socket voltages without removing the Mechanical Unit. Use the test cable for interconnecting the Mechanical and Electronic Units if the Mechanical Unit is removed. The Socket and Test Cable are included in the Spare Parts.

C. TROUBLE CHART

Trouble	Probable Cause	Remedy
1. Start motor does not turn in START position.	A. AC plug out or no AC power. B. Power Fuse Blown	A. Plug in AC power B. Turn power off and replace fuse.
2. Sync Motor tone not heard.		
A. No reading at B+ test points	A. B+ Fuse Blown. Defective V101.	A. Turn Power OFF and replace fuse. Replace V101.
B. No reading at SYNC BIAS test points	B. Defective V204, V205.	B. Replace V204, V205
C. No reading at pin 1, V203A	C. Fork Amplifier Defective	C. Check V301, V302
D. No reading at pin 2, V203A	D. Defective V203	D. Replace V203
3. Sync Motor Tone Heard but does not fall into Sync		
A. Sync drive volts reading low at pin 2, V203A	A. Sync Drive too low.	A. Adjust SYNC DRIVE. potentiometer, R213.
B. Sync drive reading normal, sync volts reading low at test points.	B. Defective V204 or V205	B. Replace defective tubes.
4. Sync Motor drops out of synchronism when band starts moving.	A. Sync Drive too low B. Defective V204 or V205	A. Adjust SYNC DRIVE. potentiometer, R213. B. Replace defective tubes.
5. Band does not move in RUN position.	A. Defective V103	A. Replace V103
6. Styli do not print.	A. Stylus not touching paper. B. Print Amplifier Defective	B. Replace stylus B. Check V201, V202.

Trouble	Probable Cause	Remedy
7. Jitter in 20 Fathom Marks	A. Bent Stylus Needles B. Stylus Holders out of index	A. Replace Stylus B. Reset index with fixture.
8. 20 Fathom Marks not printing	A. Defective V203B	A. Replace V203
9. Time Break Phasing Does not phase	A. Defective C101A power supply	A. Replace C101A
10. Ragged or No Keying	A. Defective or dirty Keying Contacts	A. Clean or replace keying contacts

IV. PREVENTIVE ROUTINE MAINTENANCE, LUBRICATION

A. PREVENTIVE MAINTENANCE

What to Check	How to Check	Precautions and Remedies
1. Gear System	Remove covers. Inspect for dirt or damage.	Clean out dirt with nylon-bristle brush or equivalent. Replace damaged parts and lubricate if necessary.
2. Exhaust System	Remove nozzle, inspect hose for cracks. Check blower motor lubrication.	Clean the nozzle. Replace hose if necessary. Lubricate blower motor when required.
3. Brushes	Examine Brushes and Wheels	Clean carbon from brushes and wheels.
4. Machine Base	Inspect for foreign matter.	Clean out foreign matter.
5. Paper feed system	Check operation of paper feed mechanism and roller ass'ys. Check paper guide finger for damage.	Clean rollers and lubricate roller shaft bearings if necessary. Replace damaged guide finger strip if necessary.
6. Keying Contacts	Check for accumulation of foreign matter and contact wear.	Clean contact shoe block once per week with clean, dry rag. Replace contacts if necessary.

B. LUBRICATION

The two types of bearings used on the PDR are ball bearings and "oilite" or oil impregnated bronze sleeve bearings.

The ball bearings do not need any cleaning or lubrication. Short of a rare need for replacement, these bearings should not be disturbed.

The "oilite" bearings do need some periodic lubrication. Despite the natural oil retention ability of these bearings, they will eventually run dry due to seepage and evaporation. To assure good operation of the machine, it is necessary to lightly lubricate all points employing these bearings at least twice a year. To do this it is only necessary to use one or two drops of a suitably light lubricating oil at each bearing point. These points are:

(1) Two oil tubes on the blower motor.

(2) The sleeve bearings at either end of the drum shaft.

(3) The sleeve bearings in the paper roll support cone bracket.

(4) Oil cup hole on synchronous clutch ring.

(5) Either end of front pressure roller shaft bearing.

All gears should be lubricated at least twice a year with a medium grease similar to Lubriko M6 or equivalent. Apply a thin film using a nylon-bristled brush or similar lint-free applicator.

NOTE: KEEP AWAY ALL GREASE AND OIL FROM THE BAND ASSEMBLY, TROLLEY BAR AND OTHER PARTS ON THE FRONT OF THE MECHANICAL UNIT.

V. MECHANICAL ADJUSTMENTS AND REPAIR

A. STYLUS HOLDER ASSEMBLY, ADJUSTMENT AND REPLACEMENT

Normally, the stylus holder assembly should require adjustment only when replacing a broken or damaged stylus leaf spring. A special tool is required for adjustment. This tool is not to be used as a check for proper alignment of a stylus holder assembly.

Before an attempt is made to adjust an undamaged stylus holder assembly, it should be determined if the holder assembly is definitely out of index (alignment). This is done by using styli in all assemblies that are known to be straight. With straight styli, an improperly indexed holder will produce 20 Fathom Marks with every third dot displaced. This displacement will be regular -- that is, appear the full width of the chart and every third line. If the pattern is irregular, faults other than the misalignment of a stylus holder are indicated.

(1) Equipment Required

1. Stylus holder mounting fixture assembly.

2. Small screw driver

3. Replacement parts if required

(2) Procedure

1. Turn power switch to START. Lift the hood.

2. Remove styli from all holders.

3. Manually rotate the left wheel clockwise until stylus assembly #1 is at 9 o'clock on the left wheel rim. (Stylus holders are identified by blue markings on the band).

4. If the sync arm is close to the stylus assembly, hold the left wheel firmly and rotate the sync arm clockwise approximately 1/4 turn or until perpendicular.

5. Refer to Figure 25. Loosen retaining screw and remove alignment pin from protective storage. Loosen the clamp screw until the threaded end no longer protrudes into the slot.

6. Mount fixture on the left wheel as illustrated in Figure 25.

7. Position fixture so that Positioning Pin #1, Figure 25, is in contact with the nylon block. Positioning Pin #2 is pressed on wheel rim. While maintaining these two contact points, press the fixture radially on the wheel rim and firmly tighten the clamp screw.

8. Loosen the stylus block screws approximately one turn.

9. Insert the alignment pin through the stylus bushing and through the fixture bushing. Insert the pin all the way through and apply sufficient pressure so that the alignment pin shoulder, stylus bushing and fixture bushing are in firm contact.

   Apply the pressure firmly along the length of the pin so as not to cock the pin or the stylus bushing. While maintaining the pressure, tighten the stylus block screws using a small screw driver.

   CAUTION: Tighten the screws carefully. Do not strip the threads in the nylon block.

10. Remove the alignment pin from the fixture. The pin should slide out smoothly.

11. Loosen the clamp screw and remove the fixture from the wheel rim.

12. Insert a stylus in the stylus bushing.

13. Align the remainder of the stylus assemblies in sequence by repeating steps 3 through 12.

14. After alignment of all stylus assemblies, the alignment pin should be returned to protective hole in fixture and locked with retaining screw.

B. ADJUSTMENT OF STYLUS PRESS SPRING (15-2-026)

Improper handling of this long wire spring may deform it so that it will not push the stylus all the way in. Adjustment may be made without any tools.

1. Lift hood of recorder.

2. Switch to START and SYNC.

3. Bring suspected stylus assembly to either the left or right hand side of the machine by revolving the wheels.

4. Remove stylus and bend wire spring towards the bushing and beyond the face of the bushing so that when released it will assume its proper position -- i.e. near the rear face of the bushing. At this setting there will be approximately 5 to 10 grams of force on the needle.

C. REPLACING STYLUS BUSHING (15-2-019)

When replacing the stylus bushings do not use forces great enough to move or damage the stylus leaf spring. Bushings will require replacement only when worn flat or damaged. The stylus bushings are hard chrome plated. The inner hole contains a jewel bearing in each end. To replace a stylus bushing proceed as follows:

1. Remove old stylus bushing by inserting the point of a pick (or small screw driver) in the "V" section beneath the bushing.

2. Slight pressure will cause the bushing to pop out. Do not use enough force to move or damage the stylus leaf spring. Hold the stylus leaf spring while doing this to prevent damage to the leaf.

3. Rotate the bushing to position the flat side where it does not contact the trolley bar. (approximately 120° is recommended).

4. Place the bushing on the leaf spring and position it so the groove around the middle is centered on the leaf spring.

5. Press firmly. The bushing will snap into position. Check that the center guide spring has fallen into the groove on the bushing.

D. CHANGING THE STYLUS BAND (15-2-031)

(1) Removing Stylus Band

1. Set Control in SYNC position.

2. Remove all styli from band. (See "changing Stylus").

3. Holding lower section of band with both hands, gradually pull band outward and off the left hand wheel while rotating the band clockwise.

(2) Installing New Band

1. Set control in SYNC position.

2. Slip new band completely around left hand wheel.

NOTE: Locate band so that end with hole of sync arm is in front of an empty lug.

3. Carefully lay top section of band onto left wheel. While rotating right wheel, gently push flat section of band completely onto it.

CAUTION: Check that band is fully engaged onto wire guides on the wheel rims.

E. REMOVAL OF MECHANICAL UNIT

1. Turn selector switch to OFF position.

2. Disconnect the cable from the Electronic Unit..

3. Disconnect the exhaust hose from the suction adapter.

4. Remove the two mounting screws at each side of the base casting and remove the Mechanical Unit.

NOTE: If stylus band is left on unit, handle Mechanical Unit with care to avoid damage to the band.

F. REPLACING KEYING CONTACTS

If the leaf-spring rotating keying contacts become bent or broken, they should be replaced as follows:

(1) With power switch in OFF position; rotate keying block assembly COUNTER-CLOCKWISE until a convenient position is reached for removal of the leaf-spring retaining screws.

(2) Remove defective leaf springs.

(3) Assemble new leaf springs, but do not tighten retaining screws down hard.

(4) Rotate keying block assembly CCW and check that leaf springs contact shoe block over area of contact shown in Figure 17. Adjust area of contact by loosening retaining screws and sliding leaf springs along keying blocks.

CAUTION: DO NOT DEFORM LEAF SPRINGS.

(5) Tighten retaining screws.

VI. ELECTRICAL ADJUSTMENTS AND MEASUREMENTS

A. SYNC DRIVE

This control is a potentiometer, R213, located on top of the Electronics Unit near the right side. (See Figure 20). R213 controls the gain of the Sync Motor Amplifier.

It should be adjusted so that each phase potential of the Sync motor is between 200 and 250 volts. The phase voltages may be read at the test points provided on top of the Electronics Unit.

B. 20 FATHOM MARK DENSITY

This control is a potentiometer, R211, located on top of the Electronics Unit near the right side. (See Figure 20). R211 controls the gain of the Fathom Mark Amplifier, V203B.

It should be adjusted so that the printed 20 Fathom Mark lines are just dense enough to be read comfortably.

C. LINE VOLTAGE

This control is a single-pole, three-position selector switch, S3, mounted at the rear of the Electronics Unit. (See Figure 22). Switch S3 selects one of three taps on the primary winding of power transformer, T101, in order to adjust the output of T101 for line voltages of 105, 115, and 125 volts.

The selector switch should be placed in the position corresponding to the actual AC line voltage. The AC line voltage may be read at the test points on top of the Electronic Unit. (See Figure 20.)

D. SOCKET VOLTAGE MEASUREMENTS

TEST CONDITIONS:

UNLESS OTHERWISE SPECIFIED ALL DC VOLTAGES ARE TAKEN ON 20,000 OHMS PER VOLT METER FROM TUBE OR CAPACITOR PIN TO CHASSIS GROUND WITH TEST ADAPTER SOCKET.
AC VOLTAGES MEASURED ON 1,000 OHMS PER VOLT METER.
SELECTOR SWITCH IN RUN POSITION.
ALL READINGS ARE IN VOLTS.

TUBE		PIN NUMBERS							
REF. DES.	TYPE	1	2	3	4	5	6	7	8
V101	5R4	NC	325DC	NC	420AC	NC	420AC	NC	325DC
V102	0A2	NC	0	NC	NC	150DC	NC	NC	---
V103	2H20	NC	0	NC	NC	NC	NC	(A) 60AC	NC
V201	6SN7	0	70DC	2.5DC	0	150DC	12DC	6.3AC	0
V202	5881	0	6.3AC	290DC	290DC	0	NC	0	26DC
V203	6SN7	0	290DC	10DC	0	27DC	0	6.3AC	0
V204	6SN7	-1DC	290DC	8DC	-1DC	290DC	8DC	6.3AC	0
V205	6SN7	-1DC	290DC	8DC	-1DC	290DC	8DC	6.3AC	0
V301	6SN7	0	50DC	1.8DC	0	85DC	7.5DC	6.3AC	0
V302	6AG7	0	6.3AC	0	-1DC	NC	17DC	0	70DC
C101	(3x15 MFD)	0	NC	290DC	NC	320DC	NC	20DC	NC

NOTES:

(A) MEASURED FROM PIN 2 OF V103.
NC NO CONNECTION.

SIGNAL VOLTAGE MEASUREMENTS

TEST CONDITIONS:

SELECTOR SWITCH IN RUN POSITION.
GAIN CONTROL AT MAXIMUM.
.5 VOLT 4 KC SIGNAL FROM AUDIO OSCILLATOR FED TO INPUT JACK.
MEASUREMENTS MADE WITH AC VTVM FROM SOCKET PIN TO CHASSIS GROUND.

TUBE		PIN NUMBERS							
REF.DES.	TYPE	1	2	3	4	5	6	7	8
V201	6SN7	.5AC	4AC	---	4AC	2.5AC	---	---	---
V202	5881	---	---	100AC	---	4AC	---	---	---
V203	6SN7	5AC	25AC	---	.025AC	2.5AC	---	---	---
V204	6SN7	15AC	250AC	---	15AC	250AC	---	---	---
V205	6SN7	15AC	250AC	---	15AC	250AC	---	---	---

E. SOCKET RESISTANCE MEASUREMENTS

TEST CONDITIONS:

POWER PLUG OUT OF AC SOCKET.
SELECTOR SWITCH IN RUN POSITION.
UNLESS OTHERWISE SPECIFIED ALL MEASUREMENTS ARE MADE FROM TUBE OR CAPACITOR PIN TO CHASSIS GROUND WITH TEST ADAPTER SOCKET.
ALL READINGS ARE IN OHMS (K = 1,000).

TUBE		PIN NUMBERS							
REF.DES.	TYPE	1	2	3	4	5	6	7	8
V101	5R4	NC	12K	NC	65	NC	65	NC	12K
V102	0A2	NC	0	NC	NC	10K	NC	NC	---
V103	2H20	NC	0	NC	NC	NC	NC	(A) 10	NC
V201	6SN7	1K	(B) 47K	1.5K	100K	(B) 250	1.5K	0	0
V202	5881	0	0	(C) 40	12K	1.3K	NC	0	500
V203	6SN7	(D) 100K	(C) 750	1K	(D) 1.2K	(B) 47K	0	0	0
V204	6SN7	500	(C) 100	150	500	(C) 100	150	0	0
V205	6SN7	500	(C) 100	150	500	(C) 100	150	0	0
V301	6SN7	1.4K	(B) 110K	2.2K	150K	(B) 50K	(D) 10K	0	0
V302	6AG7	0	0	0	100K	2.2K	(B) 280K	0	(B) 110K
C101	(3x15 MFD)	0	NC	12K	NC	12K	NC	1.7K	NC

NOTES:

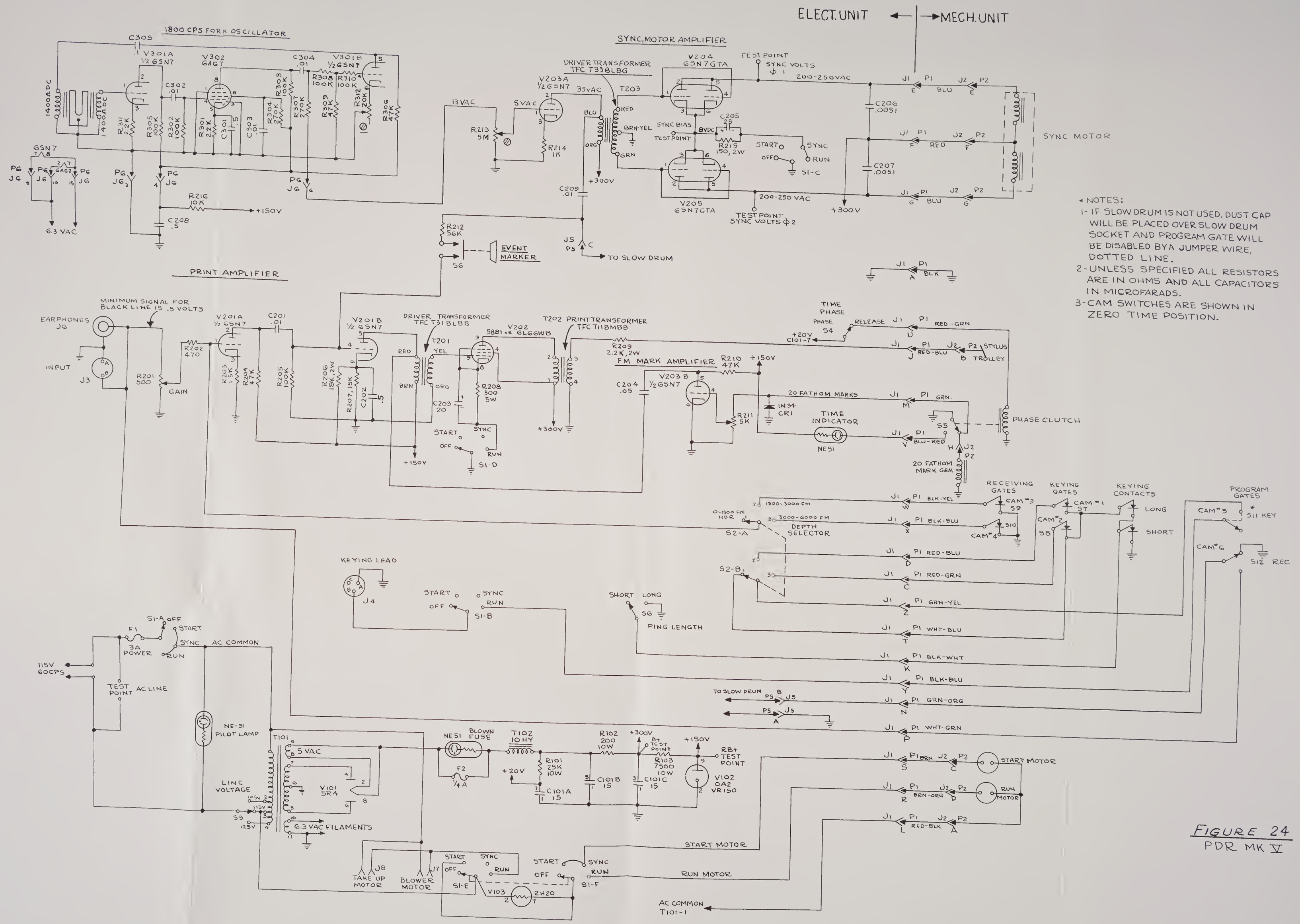
(A) MEASURED FROM PIN 2 OF V103.
(B) MEASURED FROM RB+ TEST POINT.
(C) MEASURED FROM B+ TEST POINT.
(D) VARIES WITH SETTING OF POTENTIOMETER.

SECTION SEVEN

SPARE PARTS LIST

TFC PART NO.	ITEM	SPARES PER SET
15-2-031	Band Assembly	1
19-20-001	Stylus	36
15-2-019	Bushing	9
15-2-523	Leaf Spring Assembly	6
15-2-026	Stylus Spring	6
14-56-032	Keying Contact	2
14-56-034	Contact Block	1
14-56-616	Micro Switch	2
14-56-617	Micro Switch Actuator	2
005/V000107	6SN7 Tube	4
005/V400112	6AG7 Tube	2
005/V400149	5R4 Tube	2
005/V400167	5881 Tube	2
005/V400132	OA2 Tube	2
005/V400109	2H20 Tube	2
14-56-621	1/4 Amp Fuse 3AG	10
14-56-622	3 Amp Fuse 4AG Slo-Blo	10

TFC PART NO.	ITEM	SPARES PER SET
005/V400143	NE51 Neon Lamp	2
14-56-618	Power Transformer	1
14-56-619	Filter Reactor	1
61-11-02-00	Stylus Transformer	1
41B-11-00-00	Driver Transformer	1
41B-11-03-00	Driver Transformer	1
41-00-00-27	3 x 15 MFD Capacitor	2
12-05-01-91	Pick Up Coil	1
41-00-00-31	Truarc Pliers #0018	1
41-00-00-32	Truarc Pliers #2	1
	Hex Wrench Kit	1
42-00-00-42	Truarc, 3/16"	5
42-00-00-43	Truarc, 1/4"	5
42-00-09-04	Truarc, 5/16"	5
42-00-09-05	Truarc, 3/8"	5
62-00-00-33	Truarc, 1/2"	3
15-2-132	Truarc, 5/8"	1
14-56-624	Test Cable	1
	Instruction Manual PDR MK V	1
	Test Turret Socket	1
	Stylus Holder Adjustment Fixture	1
	Instruction Manual RJ-2 Recorder	1



*NOTES:
1- IF SLOW DRUM IS NOT USED, DUST CAP WILL BE PLACED OVER SLOW DRUM SOCKET AND PROGRAM GATE WILL BE DISABLED BY A JUMPER WIRE, DOTTED LINE.
2- UNLESS SPECIFIED ALL RESISTORS ARE IN OHMS AND ALL CAPACITORS IN MICROFARADS.
3- CAM SWITCHES ARE SHOWN IN ZERO TIME POSITION.

FIGURE 24
PDR MK V

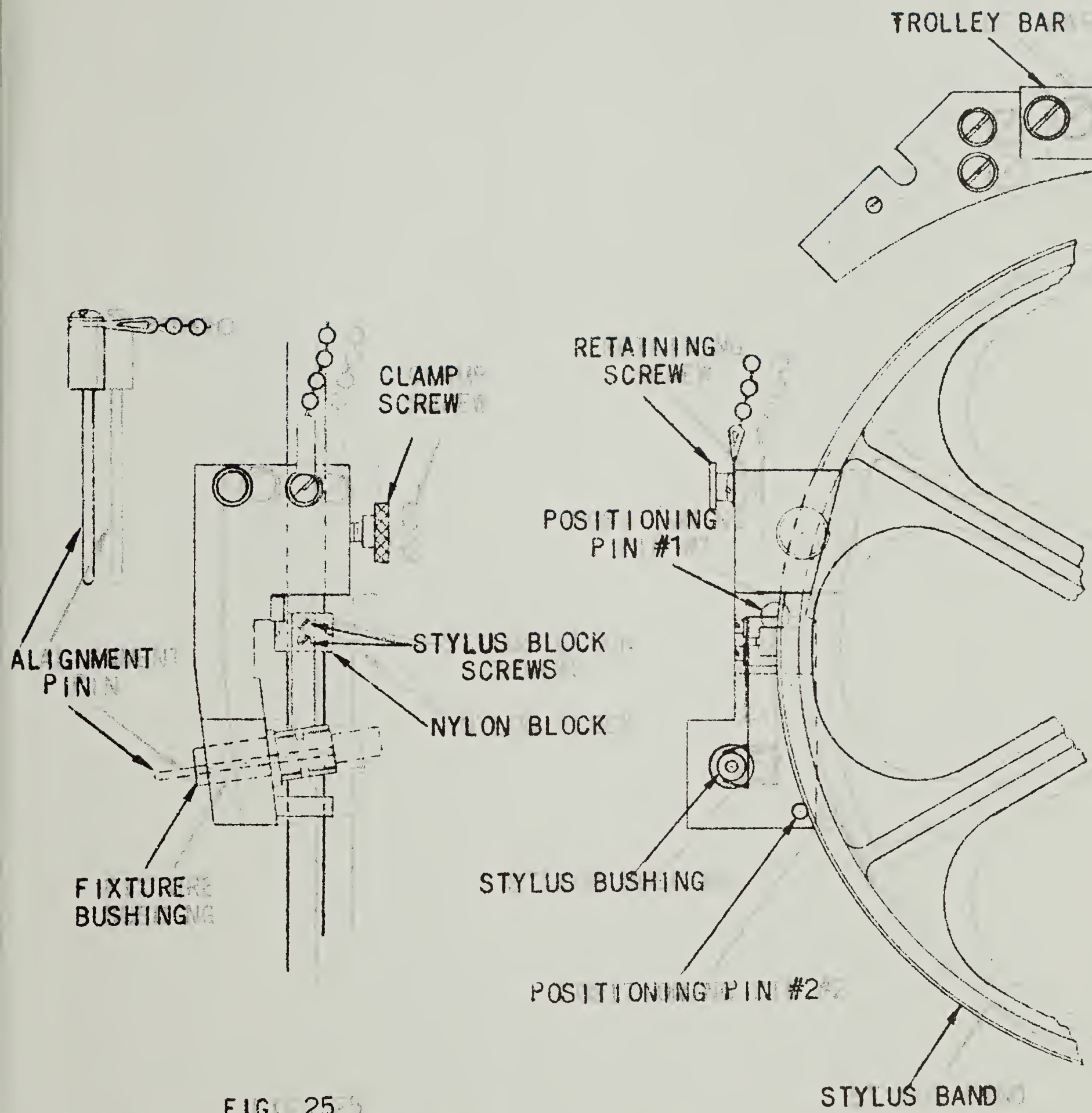


FIG. 25

STYLUS ALIGNMENT FIXTURE